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INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

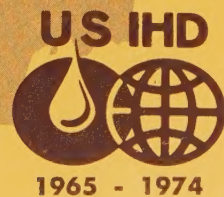
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FEBRUARY 1974

INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

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UNITED STATES

DEPARTMENT OF COMMERCE
DEPARTMENT OF DEFENSE
DEPARTMENT OF INTERIOR
DEPARTMENT OF TRANSPORTATION
ENVIRONMENTAL PROTECTION AGENCY
NATIONAL SCIENCE FOUNDATION
NEW YORK STATE DEPARTMENT OF
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CANADA

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ONTARIO MINISTRY OF THE ENVIRONMENT
ONTARIO MINISTRY OF NATURAL RESOURCES

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CANADA AND UNITED STATES

BIOLOGY AND CHEMISTRY

Panel Co-Chairmen

W. J. Christie (Canada) N. A. Thomas (U.S.A.)

In general, the goals of the Chemical and Biological Panel of IFYGL were to develop scientific information for (1) water pollution control management needs, and (2) the development of fisheries resources.

Among the water quality management problems that have been identified, accelerated eutrophication is the most often cited. It is recognized as the cause of heavy algae growths and depletion of the dissolved oxygen in the water, and these manifestations in turn, have imposed stresses on the biological communities which are believed to have contributed to the reduction of the quality of fishing. The costs of processing drinking water have increased, and in some areas the concentrations of algae render the water altogether unsuitable for domestic use. The appearance of the water in some situations is quite unpleasant, and masses of malodorous rotting algae spoil bathing beaches.

Control of the eutrophication process by limiting the nutrient inputs figures prominently in management plans for Lake Ontario. Knowledge of the present status of the lake will provide a baseline against which the success of such management measures can be gauged; information concerning the rate of change in the lake in relation to human population density may influence the choice of management strategies.

Results of the eutrophication studies within the Biological and Chemical Program will be contrasted with measurements of nutrient chemicals made in 1967 under the International Joint Commission (IJC) mandate, giving a measure of the rate of deterioration of the lake. Further, the intensive sampling to identify point sources and the background information on lake circulation that will be provided by IFYGL, will produce a more comprehensive picture of the present trophic status and of the fate of the nutrient inputs.

The effects of other non-toxic chemical inputs on the water resources of the Great Lakes is scarcely understood. The question of the significance of the rising concentrations of total dissolved solids in Lake Ontario is one example of this. Future studies will undoubtedly determine the effects of these various constituents on the health of the lake, but for the present it is of vital concern that all common chemical inputs to the lake be monitored and their disposition in the lake system be appraised.

The trophic status of the lake must be defined biologically, as well as chemically, and the intensive sampling of the biota carried on during 1972 will provide this information for all major taxa. These include algae, zooplankton, benthic organisms and fish.

The fisheries problems of Lake Ontario are of special management concern. Where the open waters once contained valuable stocks of fish such as lake trout, ciscoes, and whitefish, now only smelt and alewife are found in abundance. This has caused severe economic shock to the commercial fisheries and those surviving at the present time must subsist on low-value inshore species of fish. The sport fisheries have likewise suffered through man's interference. The accelerating need for recreational fishing opportunities near the large centres of population, and the increasing demand for freshwater fish purely as a source of protein, have given fishery management a special urgency in late years. It is generally agreed, moreover, that the best ultimate criterion of the success of efforts to improve the quality of the waters will be the kinds of fish communities they will support.

The central problem of the fisheries is that, even given control over eutrophication, over-fishing, and the parasitic sea lamprey, all of which were major factors in the decline of the fisheries, management will still face great problems in redeveloping an ecosystem which takes full advantage of the productive potential of Lake Ontario. The attainability of this goal depends heavily on an understanding of the present biota of the lake and of the interactions between its various elements. The major objectives of the fishery study were therefore to determine relative abundance of the various fish species in the lake and to measure their seasonal and spatial changes in distribution. Intensive investigation of the food habits of the major species in relation to the distribution changes and to the forage base as measured by the other investigations within the Panel, are expected to yield a picture of the food webs, and of the vectoring of materials and solar energy in the lake.

Understanding the food pathways in the biological communities of the lake will also help in understanding the transport of deleterious substances like heavy metals and pesticides through the lake system. To this end, samples of all organisms, including fish-eating birds, were analyzed.

The problem of undertaking a sampling program adequate to assess the success of management strategies is in itself a major scientific concern for all of the Great Lakes. Sampling intensity for the major chemical and biological constituents was prodigious by any standards and we stand to learn a great deal about the levels of monitoring necessary for such a large lake. There were, moreover, long-established differences in collecting, handling and analyzing both biological and chemical samples which could only have been eliminated at the expense of breaking continuity with past observations. Detailed intercomparisons were therefore carried out to reconcile the differences, and the results of these studies will also have important applications in future cooperative work around the Great Lakes.

Determining how much sampling will be needed to monitor future changes in the fish stocks was an especially important consideration. In the past the commercial fisheries contributed most of the information on stock changes, but this is no longer true because the fisheries of Lake Ontario now cover only a limited area of the lake, and this with a narrow range of types of gear (Christie 1973*). The fishing gear used for sampling is slow. The Field Year synoptic coverage for example required two trips to each station per cruise in most cases, and a total of two to three hours of vessel time at

each station. The fish themselves are highly mobile and some species school; both of which factors further compound the difficulty of obtaining consistent and reliable stock appraisals. The problem is of considerable urgency because the rehabilitation program (control of the parasitic sea lamprey, reintroduction of salmonid fishes) is already underway and a long-term international monitoring program is needed immediately.

The foregoing passages describe objectives of the core program of cooperative monitoring undertaken jointly by U.S. and Canadian Government agencies and university groups for IFYGL. The program consisted of many individual scientific tasks directed toward the study of particular phenomena or taxa, all of which contributed in an immediate way to the objectives. There were other projects which were not so directly related to the international objectives. These were in some cases programs of purely national interest, and in others, investigations which were undertaken at this time only because of the benefits of the unique background of environmental data which were collected during the Field Year.

The Chemical and Biological Program will contribute to the general advance of knowledge, but there will be an additional practical gain. While most of the sampling was based on known equipment and procedures, there were some developmental procedures which may have significance for future programs. The study of the potential of echo sounders to measure animal biomass, and remote sensing to measure Cladophora biomass are noteworthy examples, but others might be cited as well.

The sampling plan for the core biological survey combined a lake-wide synoptic collection at 60 stations, with locally intensive investigations to study such phenomena as short-term distributional changes, vertical movement and plankton grazing. This work was mainly carried out by the larger Field Year ships. The U.S. Program included intensive near-shore investigations of all elements of the biota, and most of the studies of benthic organisms. Studies of the alga Cladophora, of the phytoplankton and zooplankton were shared between U.S. and Canadian investigators.

In the fisheries program there was almost continuous sampling in the open water season along both shores where fish density and species diversity are highest. In the open lake the small vessels Cottus and Kaho provided the broadly synoptic coverage during matched cruise periods. During the intervening cruises Cottus carried out mid-water trawling at a single area to examine short-term horizontal and vertical changes in fish distribution, while Kaho collected plankton and benthic organisms.

The Chemistry Program combined lake-wide synoptic collections for water chemistry analysis, with interval measurements of chemical inputs from the streams and outputs down the St. Lawrence River. In addition certain watersheds were singled out for more detailed study of their contributions to the materials loading of the lake.

In planning the data collection effort for the Biology and Chemistry Program, every effort was made to utilize ship cruises planned for the studies of other Projects in order to maximize the information available for this Program. Sampling targets were largely met. A late start on spring Biology

and Chemistry sampling on the U.S. side, and problems caused by tropical storm Agnes occasioned the extension of the sampling to the end of June 1973. Similarly, the Canadian fisheries program had a delayed start, and undertook two replacement cruises in April and May 1973.

Summarization of the biological information will require considerably more time than will be the case with the chemistry data. Four distinct stages in the reporting can be identified for any taxon as follows:

(1) Status

Species composition, relative abundance distribution.

(2) Life History, Production, Intra-taxon Relationships

Biomass (where applicable) turnover, transport and/or movements, grazing rates (zooplankton), food and feeding, growth rates (fish), fecundity and maturity (fish) etc.

(3) Inter-taxon Relationships

Food pathways; includes primary productivity and local pollution effects, etc.

(4) Generalized Models

Items (2) and (3) are not altogether separate, since feeding studies span various biological groupings. The inputs to (3), however, will to an important extent consist of published works in (1) and (2). Inputs from other panels occur at all three levels and the materials balance data enter at (2) and (3).

The fourth level of analysis is not so predictable in its products since they depend to an important extent on the success of previous analyses. In this area would be included models of lake productivity based either on localized or whole-lake observations. Such efforts are essential from the point of view of water quality management strategy.

* CHRISTIE, W. J. 1973. A Review of the Changes in the Fish Species Composition of Lake Ontario. Great Lakes Fish. Comm. Tech. Bull. No. 23 pp 1-65.

CANADA

Editor

Brian O'Donnell

Editorial assistance
and typing

Alix O'Hara

EDITOR'S NOTE

Canadian Projects, Supplement 4, was the last in this series of publications as outlined in the Compiler's Foreword of the primary issue in March 1972. This terminates a useful mechanism for project leaders to keep current with the status of other projects.

In order to avoid a break in this mode of communications, future IFYGL Bulletins will be used as a replacement vehicle. It is hoped that all project leaders will continue to forward periodic status for use in future Bulletins.

B. J. O'Donnell
Canadian Coordinator
IFYGL

CANADIAN PANEL CO-CHAIRMEN'S REPORTS

BIOLOGY AND CHEMISTRY PANEL REPORT

W. J. CHRISTIE

Mr. Christie has included his Panel Report in the first section of this Bulletin.

ATMOSPHERIC BOUNDARY LAYER PANEL REPORT

F. C. ELDER

Status of Canadian Boundary Layer Projects*Direct Measurement of Energy Fluxes (5BL) - M. Donelan*

Analyses of profile measurements are partially completed and progress is rapid. Eddy flux measurements are delayed awaiting improvement in computer hardware to accomplish digitization.

Two papers are in preparation for the IAMAP - IAPSO Conference.

1. Some observations of the effect of wind speed and atmospheric stability on the rate of growth of surface gravity waves.
2. Adjustments of the over water atmospheric boundary layer profiles to changes in synoptic conditions.

*Space Spectra in the Free Atmosphere (15BL) - G. A. McBean,
E. G. Morrissey*

Turbulence measurements from the tower mounted instruments are not yet analyzed: Some aircraft measurements have been processed and early results are to be reported at the IAMAP - IAPSO Conference in a paper, "Variations of Turbulent Fluxes of Momentum, Heat and Moisture over Lake Ontario".

*Momentum, Heat and Moisture Transfer (28BL) - H. C. Martin, G. A. McBean
R. J. Polavarapu*

Early analysis is completed and a paper submitted for publication in the Proceedings 16th Conference on Great Lakes Research. "Latent and Sensible Heat Fluxes over Lake Ontario".

Analysis of Energy Fluxes (44BL) - F. C. Elder

Preliminary analysis of data collected by the Canadian Buoy network are completed and the results are reported to the IFYGL Data Bank. Two papers have been prepared and a third report submitted.

1. Hamblin, P. F. and F. C. Elder "A Preliminary Investigation of the Wind Stress Field over Lake Ontario", 16th Conference on Great Lakes Research.
2. Elder, F. C. "Some Results of Direct Measurement of the Bowen Ratio over an Open Lake Surface", 16th Conference on Great Lakes Research.
3. Elder, F. C. "Preliminary Estimates of Energy Fluxes for Lake Ontario for the period 19 April through 5 December 1972, presented to the Energy Balance Panel IFYGL.

Wind and Temperature Fluctuations (75BL) - S. D. Smith, E. G. Banke

First analysis are complete and results reported to the IFYGL Data Bank. A paper "Eddy Flux measurements over Lake Ontario", has been submitted to Boundary Layer Meteorology for publication.

Meteorological Buoy Measurements (97BL) - F. C. Elder

All Canadian Meteorological Buoy Measurements made during the primary phase of IFYGL have received preliminary verification and have been submitted to the Data Bank. Data from the IFYGL extended period April to August 1973 are now being verified for submission.

Air Pollution Sinks (107BL) - R. W. Shaw, D. M. Whelpdale

One paper has been published and a second submitted for publication:

1. Shaw, R. W. and D. M. Whelpdale, "Sulphate Deposition by Precipitation into Lake Ontario, Water, Air and Soil Pollution", Vol. 2, 1973 pp 125-128.
2. Whelpdale, D. M. and R. W. Shaw, "Sulphur Dioxide Removal by Turbulent Transfer over Grass, Snow and Water Surfaces", presented at the Commission for Atmospheric and Global Pollution, Symposium on trace Gases, Naing, Germany and submitted for publication in Tellus.

ENERGY BALANCE PROGRAM

G. K. RODGERS

Unavailable at this time.

LAKE METEOROLOGY AND EVAPORATION PROGRAM
J.A.W. McCULLOCH

Status as of December 1, 1973

The Atmospheric Water Balance Study (66ME), and Shoreline Evaporation Pan Network (65ME) Projects will have been reported by the U.S. Co-chairman. The Radar Precipitation (23ME) Project has completed daily precipitation maps for the Field Year period, and will report more completely in the next Bulletin.

The remaining Canadian projects are of two classes; (a) acquisition of core data, and (b) data analysis. The core data programs are:

Airborne Radiation Thermometer Surveys (16ME) - J. G. Irbe

The survey program is complete, and the isotherm analysis for each has been given wide circulation. Copies of these maps are on file at the two national data banks. A paper is being planned for the IAGLR meeting next summer.

Bedford Tower Program (20ME) - J. A. W. McCulloch

The data must wait for completion of the reduction of the shoreline data (21ME).

Canadian Shoreline Network (21ME) - J.A.W. McCulloch

Data Management is about 60% complete and, after a severe setback in which one disk file was accidentally blanked, is back on track, although considerably behind schedule.

Island Precipitation Network (27ME) - J. A. W. McCulloch

Data for the April through September 1972, period have been published in the periodical "Supplementary Precipitation Data", Vol. 4, No. 2. Data for the last six months of IFYGL will be available shortly.

Of the analysis projects, some require data which are not yet available. These include:

- 22ME - Synoptic Studies - M. S. Webb
- 26ME - Wind and Humidity Ratios - M. S. Webb
- 64ME - Basin Evapotranspiration - H. L. Ferguson

For the rest, the following status reports are presented.

Climatological Studies (24ME) - D. W. Phillips

"IFYGL Weather Data" has been published and distributed for April 1972, through March 1973. (They compare the temperature and precipitation data from the basin climate stations with long-term normals). April 1973, is ready for printing, and May and June 1973, will be available in due course.

Evaporation by Mass Transfer (25ME) - J. G. Irbe

Evaporation Synthesis (62ME) - J. A. W. McCulloch

These are treated in some detail elsewhere in this Bulletin.

Surface-Water Temperature Distribution (67ME) - M. S. Webb

The previous long-term averages have been updated to include data to the end of 1971. Data from the Field Year months have been plotted for each grid point and the analysis begun.

TERRESTRIAL WATER BUDGET PROGRAM

D. F. WITHERSPOON

The basic data for computation of the monthly water balance of the Lake Ontario (11TW) land basin have been compiled through February 1973. Estimates of evaporation from Lake Ontario for the Field Year computed from the water balance of Lake Ontario (12TW) were coordinated with U.S. investigators and distributed in November. These will be further revised as final estimates of rainfall on the lake surface are received. A report in the Scientific Series No. 34 of the Inland Waters Directorate of the Water Resources Branch on Airborne Measurement of Snow-Water Equivalent using Natural Gamma Radiation over Southern Ontario, 1972-1973 based on snow cover data, some of which was gathered as part of the IFYGL, was published in November 1973.

Groundwater Contribution to Lake Ontario (38TW) - R. C. Ostry

This was reported on in Bulletin No. 6.

Groundwater Flow (completed) (13TW) - D. H. Lennox

St. Lawrence-Niagara River Measuring Program (46TW) - E. A. MacDonald

These have been completed.

Progress reports on the remainder of the Terrestrial Water Budget Panel projects are not available at this time.

CANADIAN WATER MOVEMENTS ACTIVITIES

E. B. BENNETT

Inter-project Activities

In the current meter and meteorological time series data obtained at Canadian moorings, two episodes were evident when the wind forcing was markedly above background levels, and when, as a consequence, the lake behaviour could be related to a dominant cause. These episodes Hurricane "Agnes" 20-30 June, and Storm "Betty", 7 - 17 August) are being analyzed in a manner that will provide a means of developing comprehensive energy and momentum budgets for the lake, and a basis for verification of mathematical models. As a first step, descriptive summaries of each episode have been prepared in the form of graphical displays.

Current meter time series information has been provided as additional data for the analysis in the coastal jet studies and in the investigations of long period internal waves.

Tower Study (34WM) - G. K. Rodgers

Project is complete.

Coastal Chain Study (40WM) - G. T. Csanady

The data report has been published, as have two papers in Journal of Physical Oceanography:

"Wind-induced barotropic motions in long lakes"

"Transverse internal seiches in large oblong lakes and
marginal seas"

A third paper entitled "Spring thermocline behaviour in Lake Ontario" has been submitted to JPO, while a fourth, entitled "Baroclinic coastal jets in Lake Ontario during IFYGL" is being prepared jointly with Jon Scott, SUNY.

Internal Wave Measurements (43WM) - F. M. Boyce

Data editing is finished and presentation is being finalized. Interpretation, particularly in regard to transient response of the lake to wind impulses, is well under way in this joint Canadian-U.S. effort.

Lake Current Measurements (45WM) - E. B. Bennett

All data have been edited and entered in the data bank. A graphical summary of current speed and direction and water temperature information obtained from each meter has been prepared, as has a file of hourly averages.

Velocity spectra and decompositions of the time series into "net" and "inertial" components have been computed for half of the records.

Surface Wave Studies (76WM) - G. L. Holland

All data obtained have been analyzed and summarized in several forms, copies of which are available on request. In particular, plots of significant wave height as a function of time were made; these serve also to indicate when data were obtained.

Turbulent Diffusion Studies (89WM) - C. R. Murthy

The data obtained during mid-lake or deep water experiments have been analyzed and interpreted; this work is summarized in a report entitled "Large scale Diffusion Studies". Analysis and interpretation of data deriving from nearshore experiments is underway.

Hydrodynamical Modelling (95WM) - J. Simons

Model results were compared with field observations made during the Hurricane Agnes period in a paper presented at the last IAGLR Conference. The field observations from the period 7 - 17 August (Storm "Betty") have been reduced to enable a similar comparison. A comprehensive modelling paper is in preparation.

Upwelling Study (109WM) - G. K. Rodgers

The limnological data have been edited and submitted to the IFYGL data bank. Temperature data obtained during the upwelling episode in early August have been analyzed, and will be discussed in a report along with the pertinent radiation and meteorological data.

Hydro Intake Study (110WM) - A. Arajs

All temperature and current velocity data are entered in the IFYGL data bank. Temperature and current summary reports are being prepared on a site-by-site basis.

Lakeview Dispersion Study (111WM) - M. D. Palmer

All data are in the IFYGL data bank. The data were used in a paper entitled "Assessment of a waste outfall" which was presented at the last IAGLR Conference, and in a report entitled "Assessment of a location of an outfall for Peel County project".

EVAPORATION SYNTHESIS

J. A. W. McCulloch

One major goal of the IFYGL has been to improve our ability to estimate evaporation from large lakes. Several separate projects were to make essentially independent estimates which were then to be studied by an Evapoaration Synthesis task group. The separate approaches to calculating evaporation were:

- (a) as a residual in the terrestrial water budget (whole year);
- (b) as a residual in the lake energy budget (whole year);
- (c) as a portion of the atmospheric energy budget (selected intervals September through December, 1972);
- (d) from aerodynamic equations using buoy meteorological data (April through December);
- (e) from direct energy flux measurements (selected periods);
- (f) from mass transfer equations using climatological data from the basin networks and from surface-water temperature data from ART Surveys (whole year).

The final estimates have been made for the mass transfer approach using climatological data, and preliminary estimates based on incomplete data have been distributed by the Terrestrial Water Budget Panel and by Floyd Elder from the buoy observations.

The Table 1 overleaf presents the available preliminary estimates for comparison. The following must be kept in mind while studying these results:

- (a) TWB (Terrestrial Water Budget) - estimates have been made without measurements of over-water precipitation from the Precipitation/Radar Task Group. That factor was only estimated, so there is still room for further adjustment.
- (b) FCE (Floyd Elder) - had access to data from the Canadian buoys only. When data from the U.S. buoys become available, the calculations will be redone.
- (c) MTM (Mass Transfer - monthly) - the AES regularly makes monthly evaporation estimates based on monthly mean climatological data and a monthly mean surface-water temperature. The estimates in this column were made using that routine approach.
- (d) MTD (Mass Transfer - daily) - because weekly ART flights were made during the Field Year, it was feasible to modify the standard approach (MTM above) and attempt daily estimates. In these were used interpolated areal mean surface-water temperatures and data from first-order land stations. The figures in Table 1 represent a summation of these daily values.

Table 1. Monthly Evaporation Estimates (cm)

	(a) TWB	(b) FCE	(c) MTM	(d) MTD
April	1.02		-1.02	1.88
May	1.53	-0.06	-1.04	-2.99
June	2.54	-0.45	-3.71	-5.33
July	5.34	2.22	-0.99	1.18
August	9.13	4.82	3.58	7.49
September	9.65	9.41	7.95	10.40
October	13.21	12.85	9.78	10.01
November	6.86	9.54	7.75	6.93
December	5.58		5.61	7.04
January	8.13		7.66	8.08
February	4.57		6.65	6.19
March	-0.51		0.00	1.32
		<u>Totals</u>		
Aug-Nov.	38.85	36.62	29.06	34.80
May-Nov.	47.96	38.33	23.32	27.69
Aug-Mar.	56.62		48.98	57.43
Apr-Mar.	67.05		42.22	52.17

Table 1 has some good news and some bad news. In the latter category, might be included the poor agreement during the first four months of the Field Year. The Water Balance showed evaporation of 10.43 cm while the monthly mass transfer (MTM) estimated condensation totalling 6.76 cm and condensation of 5.26 cm was estimated by daily mass transfer (MTD).

The picture brightens when the rest of the year is scanned. For the August through November period, columns (a), (b) and (d) show an encouraging resemblance, and columns (a) and (d) are remarkably similar for August through March. However, because of the discrepancies during the meteorologically stable period, comparisons over the whole year, or that portion of it through which buoy data are available, are not satisfactory.

These conclusions, then, may be made at this time, remembering that two sets of estimates (columns (a) and (b)) are still tentative.

- (1) Over the "strong evaporation period" of the year, the totals estimated by TWB, FCE and MTD are encouragingly similar even though individual months show much more scatter.
- (2) For the period of IFYGL at least, modifying the mass-transfer approach to use daily observations rather than monthly mean climatological data appears to have made a significant improvement in total.
- (3) The Evaporation Synthesis task will not be an easy one. The data in column (a) were provided by the Terrestrial Water Budget Panel. Those in column (b) were prepared by Floyd Elder at CCIW. J. G. Irbe made the estimates reported in columns (c) and (d).

CANADIAN PROJECT REPORTS

LAKE ONTARIO EVAPORATION

(IFYGL Project #11TW)

On the basis of the provisional data furnished the Terrestrial Water Budget Panel, the evaporation from the water surface of Lake Ontario is estimated to be as follows:

April	1972	=	+0.4 ins.
May	1972	=	+0.6 ins.
June	1972	=	+1.0 ins.
July	1972	=	+2.1 ins.
August	1972	=	+3.6 ins.
September	1972	=	+3.8 ins.
October	1972	=	+5.2 ins.
November	1972	=	+2.7 ins.
December	1972	=	+2.2 ins.
January	1973	=	+3.2 ins.
February	1973	=	+1.8 ins.
March	1973	=	-0.2 ins.

Further estimates will not be made until final data is available.

AIRBORNE ICE RECONNAISSANCE

(IFYGL Project #63EB)

Ice Reconnaissance on Great Lakes - Winter 1972-73

Lockheed Electra L-1880 CF-NAY

DATE	AREA COVERED	SENSORS USED		
		VINTEN CAMERA	THERMAL MAPPER	LASER
27/12/72	L. Huron, L. Superior			X
30/12/72	L. Huron, L. Superior	X	X	
31/ 1/73	L. St. Clair, L. Erie, L. Ontario	X	X	
25/ 2/73	L. Huron, L. Erie, L. Ontario	X	X	

Total number of Flights - 4 Total Flight Time - 44 hrs. 8 min.

Laser profilometer on analogue chart. Vinten Camera and Thermal Mapper on 70 mm Black and White Film (negative only).

Douglas DC-3 CF-HTH

DATE	AREA COVERED	NIL SENSORS
11/1/73	L. Ontario, L. Erie, L Huron	
12/1/73	L. Superior, Georgian Bay	

Total number of Flights - 2

Total Flight Time - 17 hrs. 0 min.

AIRBORNE ICE RECONNAISSANCE CONTINUED*DOUGLAS DC-4 CF-KAE*

DATE	AREA COVERED	NIL SENSORS
7/12/72	Georgian Bay L. Superior, L. Huron	
15/12/72	Georgian Bay L. Superior, L. Huron	

Total Number of Flights 2

Total Flight Time 14 Hrs. 55 min.

CESSNA SKYMASTER CF-DOL

DATE	AREA COVERED	NIL SENSORS
8/1/73	L. Ontario	
9/1/73	L. Ontario, L. Erie	
25/1/73	L. Erie	
9/2/73	L. Ontario, L. Erie	
22/2/73	L. Ontario	

Total Number of Flights 5

Total Flight Time 18 hrs. 10 min.

Summary

Total Number of Flights 55

Total Flight Time 330 Hrs. 26 Mins.

Shore Station Ice Observations

Kingston, Ontario	-	Dec. 17 - March 25
Wiarton, Ontario	-	Dec. 31 - April 1
Parry Sound, Ontario	-	Dec. 22 - April 13
Goderich, Ontario	-	Dec. 15 - March 25
Sarnia, Ontario	-	Dec. 9 - April 1
Toronto Island, Ontario	-	Dec. 17 - April 1
Sault Ste Marie, Ontario	-	Dec. 10 - April 1
Owen Sound, Ontario	-	Jan. 7 - April 1
Michipicoten Harbour, Ontario	-	Dec. 31 - April 1
Thunder Bay, Ontario	-	Feb. 4 - March 27

Ice Thickness Reporting Stations

Thunder Bay, Ontario	-	Jan. 24 - Feb. 28
South Baymouth, Ontario	-	Dec. 28 - March 29
Sault Ste. Marie, Ontario	-	Feb. 5 - March 26 (4 Observing Sites)
Welland Canal, Ontario	-	Jan. 29 - March 12 (6 Observing Sites)

Ice Reconnaissance on Great Lakes - Winter 1972-73 (Continued)*Aztec C CF-PUX*

DATE	AREA COVERED
27/12/72	Lake Ontario
29/12/72	Lake Ontario
2/ 1/73	Lake Ontario
8/ 1/73	Lake Ontario
10/ 1/73	Lake Ontario
12/ 1/73	Lake Ontario
17/ 1/73	Lake Ontario
25/ 1/73	Lake Ontario
5/ 2/73	Lake Ontario
13/ 2/73	Lake Ontario
23/ 2/73	Lake Ontario
28/ 2/73	Lake Ontario
8/ 3/73	Lake Ontario
9/ 3/73	Lake Ontario
16/ 3/73	Lake Ontario
20/ 3/73	Lake Ontario

Total Number of Flights 16

Total Flight Time 74 Hrs. 23 Min.

*ART Survey Conducted by J. G. Irbe, Project #16

CANADIAN COAST GUARD SHIP GRIFFON

AES Ice Observer - R. M. Hiechie
 Total No. Helicopter Flights - 7
 Total Flight Time - 9.5 Hrs.
 Total No. of Days on Ship - 84

BASIN EVAPOTRANSPIRATION

(IFYGL Project #64ME)

Objective

The objective is to obtain monthly distributions of actual evapotranspiration over the Canadian land portion of the Lake Ontario Basin during the Field Year.

Method

The basic technique has been developed by the Hydrometeorological Research Section of AES and tested in the Okanagan Basin of British Columbia.

Mean monthly "lake evaporation" based on longer-term climatological data for Class A pan network stations are tabulated. These values represent mean evaporation from small lakes or ponds. Regression equations are derived which relate this variable to physiographic factors. These equations are used to obtain values of mean monthly "lake evaporation" for grid areas of 400km^2 . For the 136 grid areas, vegetative cover characteristics and physiographic factors are used to obtain mean ratios of actual evapotranspiration to "lake evaporation". Grid values of mean monthly actual evapotranspiration are then tabulated. For the individual months of the Field Year deviations from normal are tabulated and interpolated. The deviation field is added to the mean field to obtain preliminary monthly evapotranspiration maps.

A similar procedure is followed to obtain preliminary monthly precipitation fields. An optimization technique involving the water balance equation is then applied to adjust the precipitation and evapotranspiration fields so that they are consistent with observed runoff.

Activities and Accomplishments

Vegetative cover characteristics and a number of other regression parameters have been analyzed and tabulated for grid areas and climatological stations. Derivation of regression equations is in progress.

Team Members - H. L. Ferguson, W. D. Hogg

MEAN MONTHLY SURFACE TEMPERATURES OF LAKE ONTARIO DURING IFYGL

(IFYGL Project #67)

As part of the contribution by the Canadian Atmospheric Environment Service to IFYGL, frequent aerial surveys of the surface temperatures of Lake Ontario were made (IFYGL Project 16). To assist in the application of these temperature data, IFYGL Project 67 was planned in order to reveal the spatial patterns in mean surface temperatures by month during the period January 1972 through March 1973 inclusive. It is planned to publish the results of this study as a Climatological Study by the A.E.S.

The initial analysis of these surface temperature data proceeded on the assumption that mean monthly temperatures could be determined using regression equations to approximate the seasonal change in temperature with date at some 90 points on the lake. Such a procedure had proven very successful when data for several years were available. However, when only one year of data was available, this regression technique proved unable to meaningfully cope with the often widely fluctuating temperature of the lake's surface.

As a result, the surface temperature data are being analysed by hand (as described in Webb (1970)). Monthly patterns at mean surface temperature should be completed early in the new year.

Webb (1970) Monthly Mean Surface Temperatures for Lake Ontario as
Determined by Aerial Survey

Water Resources Research, 6(3), 943 - 956

COOPERATIVE STUDIES OF FISH STOCKS - CANADIAN PART

(IFYGL Project #83BC)

Principal Investigator

W. J. Christie, Glenora Fisheries Station, Ontario Ministry of Natural Resources, R.R. #4, Picton, Ontario.

Cooperating Agencies

Ontario Ministry of Natural Resources -

Southern Research Station (K. H. Loftus)
Lake Erie Fisheries Research Unit (S. J. Nepszy)
Lake Ontario Management Unit (J. M. Byrne)
Glenora Fisheries Station (W. J. Christie, D. A. Hurley)

Ontario Ministry of the Environment - Biology Branch (M. Michalski)

Environment Canada - Fisheries Research Board Detachment, CCIW
(M. J. Johnson)

Royal Ontario Museum (E. J. Crossman)

Queen's University (M. Bristow)

Dalhousie University (E. T. Garside)

Objectives

To establish the size, stock and distribution of various fish types, and study the food (and pollutant) pathways from one species to the other. To assess research vessel sampling as a means of monitoring the success of present and future management activities.

Progress

Refit problems caused a delay in the start of the sampling season for R. V. Cottus. Four 17 day synoptic cruises were completed in concert with the U.S. B.S.F.W. program however. The lost spring synoptic cruise was completed in the spring of 1973. The design for the main lake synoptic program involved sampling at 25 stations in each cruise. Graded mesh gangs of gill-nets were fished at each station and a bottom trawl drag was completed at each of the stations where the bottom was smooth.

Gear specifications and fishing procedures were the same as in the U.S. program but the sampling pattern was not identical on both sides of the lake. One potentially useful departure from earlier coordination plans involved the Canadian use of six index sampling stations in the Eastern Outlet Basin which

have been used each summer since 1959. This will give the IFYGL data a long-term context in that area at least. The total for the Field Year synoptic coverage was 119 gillnet sets (each totalling 1675 yards of netting), and 73 one-half mile bottom trawl drags. Attempts to complete a mid-winter cruise were frustrated by weather conditions and only a few stations near Toronto were visited.

Cruises in September and October by Cottus were given over to vertical sampling with a pelagic trawl and a final such cruise was completed in May 1973. In this program three of the stations along the eastern basin transect which were located near the shore, at an intermediate distance and at mid-lake, were fished day and night at three depths over the seventeen day cruise period. This sampling technique is new to Lake Ontario fisheries research, but it quickly proved practical and efficient. Ninety-four one mile drags were carried out.

In keeping with the greater species diversity, the near-shore program was both intensive and diversified with respect to gears used. The vessel Keenosay of the OMNR Lake Erie Unit devoted 3 ten day cruise periods to near-shore pelagic trawling and gill-netting. Shore-based crews manned three primary and two secondary stations along the length of the lake, carrying out almost continuous beach seining and gillnetting through the summer months. Trapnetting and electro-fishing further augmented some of the collections. The Royal Ontario Museum undertook to extend the spatial coverage of the beach seining so as to ensure as complete a species list as possible. Technical difficulties impaired the 1972 program, and the deficiencies were made up by museum field parties during the summer of 1973.

The Bay of Quinte work represented a discrete component in the Canadian near-shore program. This was the first year of a long-term study of the biological consequences of the tertiary sewage treatment soon to be instituted by the Bay communities, and consists of an integrated broad program of biological and physical limnology. Among the cooperating agencies listed at the outset, Ontario Ministry of the Environment, Environment Canada and Queen's University were all cooperators in this study but not engaged in fisheries studies per se.

Sub-samples of fish were returned from all over Canadian Lake Ontario to the Glenora Fisheries Station where the detailed examinations were carried out. Table 2 summarizes the collections.

Table 2. IFYGL Summary of Fish Sampling

Sampling Gear	No. of Species	Total Fish Caught	No. Tagged & Released	Size, Age, Sex	Samples Retained Stom. Analyses
Bottom Trawl	28	81834		5872	1362
Pelagic Trawl	7	152488		5385	2907
Gillnets	34	103238		23483	3512
Seines	44	21852		2184	1406
Trapnets	26	47967	2784	2783	3
Total	139	407379	2784	39707	9190

The volume of data is large and it will be some time before the analyses are completed. Most of the Canadian analyses will be completed at Glenora, some of which will be pooled with similar studies of the U.S. material and published by co-authorship. Some of the near-shore material will be analysed by the Lake Erie fisheries research group and all the threespine stickleback data will be analysed at Dalhousie University. The alewife data are to be sent to Ann Arbor for analysis by the U.S. B.S.F.W. staff, while the U.S. smelt data will be pooled and analysed with the Canadian materials at Glenora.

While analyses have not progressed far at this date (September 1973), some preliminary observations are worthy of note. Several specimens of the fourhorn sculpin (Myoxocephalus quadricornis) a large sculpin of the abyss of the lake, were captured. The species had not been seen since 1952 and had been considered extinct. The formerly abundant deepwater ciscoes of the genus Coregonus were taken in small numbers in a U.S. survey of 1964, but were completely absent from the much more intensive Field Year collections, suggesting they may now have reached extinction. The pelagic trawling revealed impressive numbers of smelt and alewife in the upper waters from the north shore line to mid-lake, a finding for which there was no precedent. Finally, the range of species as shown above is still impressively large, but it was not surprising to find that the fish population of the lake consists to a very great extent of the three introduced species alewife (Alosa pseudoharengus) rainbow smelt (Osmerus mordax) and white perch (Morone americana) and the only native species still in great abundance is the yellow perch (Perca flavescens)

AES STUDIES OF AIR POLLUTION SINKS ON LAKE ONTARIO

(IFYGL Project #107BL)

1. The project to measure vertical gradients of sulphur dioxide over water in order to estimate its flux into the Lake has been completed. The data has been analyzed and results have been reported in a presentation entitled,

"Sulphur dioxide removal by turbulent transfer
over grass, snow and water surfaces".

by D. M. Whelpdale and R. W. Shaw at the CACGP Symposium on Trace Gases.

2. The project to determine sulphate input to Lake Ontario from precipitation has been completed. The samples have been analyzed and results reported in a paper entitled,

"Sulphate deposition by precipitation into Lake Ontario"

by R. W. Shaw and D. M. Whelpdale, published in Water, Air and Soil Pollution, 2 (1973), 125 - 128.

AIRBORNE GAMMA-RAY SPECTROMETER SNOW SURVEY

(IFYGL Project #116TW)

Results of the gamma-ray spectrometer snow surveys indicate that with the Geological Survey of Canada's airborne spectrometer systems the average water equivalent of the snowpack over 16 km. line sections can be measured to an accuracy of 1.2 cm (root-mean-square derivation between ground and airborne results) using the potassium count information, and to 1.7 cm. using total radio activity.

The largest errors arose from background variation along the flight lines and from lack of accurate soil moisture data. Statistical errors associated with the gamma-ray radiation were small over 16 km. sections.

Results are published in the following publications:

Loijens, H. S. and R. L. Grasty (1973) Airborne measurement of snow-water equivalent using natural gamma radiation over southern Ontario, 1972-1973. Scientific Series No. 34, Water Resources Branch, Environment Canada, Ottawa.

Grasty, R. L., H. S. Loijens and H. L. Ferguson (1973) An experimental gamma-ray spectrometer snow survey over Southern Ontario. Paper presented at the Interdisciplinary Symposium on advanced concepts and techniques in the study of snow and ice resources. Montorey, California, December 2 - 6, 1973.

CANADIAN IFYGL PUBLICATIONS

At the request of the Joint Management Team, the following list of Canadian IFYGL publications has been compiled. This list represents those publications currently on file at the Canadian Data Bank in Burlington. Project leaders are encouraged to submit all IFYGL publications to the data bank (8 copies of each are required, 4 of these will be forwarded to the U.S. data bank).

Please address the above to:

Mr. J. W. Byron,
IFYGL Data Bank,
Canada Centre for Inland Waters,
P.O. Box 5050,
BURLINGTON, Ontario, L7R 4A6.

B. O'Donnell
Canadian Coordinator
IFYGL

GENERAL FIELD YEAR PUBLICATIONS

1. IFYGL Bulletins Nos. 1 - 7.

2. IFYGL Technical Plans, Volumes 1, 2, 3 and 4.

3. IFYGL Canadian Projects, March 1972

Canadian Projects Supplement	#1	-	July 1972
"	"	"	#2 - October 1972
"	"	"	#3 - February 1973
"	"	"	#4 - June 1973

4. IFYGL Technical Manual Series -

#1	Methods of Measuring Soil Moisture by R. G. Wilson
#2	Radiation Measurement by J. Ronald Latimer
#3	Measurement of Currents in the Great Lakes by M. D. Palmer

Bolsenga, S. J. and MacDowall, J. 1970. Plan of Study for the International Field Year for the Great Lakes, Proc. 13th Conference, Great Lakes Res. 1970.

McCulloch, J.A.W. 1973. "The IFYGL" Paper given at the Helsinki Symposium on Hydrology of Lakes, 1973. A.E.S.

Richards, T. L. 1967. "Hydrometeorological Studies in Support of IFYGL. Extract of "Hydrological Aspects of the Utilization of Water". A.E.S.

Richards, T. L. 1970. "The Scientific Program of the IFYGL". Presented at the A.A.A.S. Meetings, Chicago, 1970. A.E.S.

Richards, T. L. and Drescher, W. J. 1970. "The IFYGL, an example of an International, Interagency and Interdisciplinary Approach to a Research Program in Water Resources". Prepared for presentation to the Water Management Research Group, Organization of Economic Development, 1970 North American Tour, at Burlington, Ontario, 1970.

PROJECT PUBLICATIONS

IFYGL Status Report, June 1973. Atmospheric Environment Service, Boundary Layer Research Division, Downsview, Ontario.

- #1F THOMSON, K.P.B., 1973. High Altitude Remote Sensing Surveys of Lake Ontario, Canada Centre for Inland Waters, Burlington, Ontario.
- #13TW HAEFELI, C. J., 1973. Groundwater Inflow into Lake Ontario from the Canadian Side (IHD Project GW 68-3) Scientific Series No.9, Canada Centre for Inland Waters, Burlington, Ontario.
- #13TW HAEFELI, C. J., 1973. Regional Groundwater Flow between Lake Simcoe and Lake Ontario, Canada Centre for Inland Waters, Burlington, Ontario.
- #15BL PRENTICE, D.W.B., 1973. Reduction and Preliminary Analysis of Mesoscale Meteorological Data Provided by N.A.E. Low Level Research Flights in Connection with the IFYGL Program, Technical Report, Atmospheric Environment Service, Downsview, Ontario.
- #28BL McBEAN, G. A., MARTIN, H. C. and POLAVARAPU, R. J. Momentum Heat and Moisture Transfer in the Atmospheric Surface Layer over Lake Ontario. IFYGL Status Report, June 1973. Atmospheric Environment Service, Downsview, Ontario.
- #38TW OSTRY, R. C., 1973. Hydrogeology of the Forty Mile Creek Drainage Basin of the South Shore of Lake Ontario, Ontario Ministry of the Environment, Toronto, Ontario.
- #38TW ONTARIO MINISTRY OF THE ENVIRONMENT, ONTARIO. Water Quantity Management Branch. Maps: Lake Ontario Drainage Basin: (1) Overburden well yields 5926-2
(2) Bedrock well yields 5926-1
- #40WM CSANADY, G. T. and PADE, B., 1972. Coastal Jet Project Annual Report, 1972. University of Waterloo, Ontario.
- #42EB BOYCE, F., 1972. Heat Content Survey of Lake Ontario 1972 Reports 1 through 10 inclusive. Canada Centre for Inland Waters, Burlington, Ontario.
- #54BC JOHNSTON, L. M., 1972. A Geochemical Study of Deadman Bay, near Kingston, M.Sc. Thesis in Geology, Queen's University Kingston, Ontario.

- #64ME O'NEILL, A.D.J. and FERGUSON, H.L., 1971. A spectral Investigation of Horizontal Moisture Flux in the Troposphere. Reprint from the Journal of Applied Meteorology, Vol. 10, No. 1, February 1971. Atmospheric Environment Service, Downsview, Ontario.
- #66ME FERGUSON, H. L. and SCHAEFER, D.G., 1971. Feasibility Studies for the International Field Year for the Great Lakes. Atmospheric Water Balance Project, Proc. 14th Conference Great Lakes Research, 1971 International Association, Great Lakes Research. Atmospheric Environment Service, Downsview, Ontario.
- #66ME FERGUSON, H.L. and O'NEILL, A.D.J., 1968. Feasibility Study for IFYGL SP-1, I.H.D. Project R-L-7 CAN 27. Atmospheric Water Balance over an Area of 30,000 Km². Atmospheric Environment Service, Downsview, Ontario.
- #68F SCORGIE, D.A. and WILSON, W.M., 1973. Phosphorous Concentrations as a Factor in the Eutrophication of Lake Ontario, 1972. A report by summer student for technical operations at CCIW, Burlington, Ontario.
- #75BL SMITH, S. D., 1973. Eddy Flux Measurements over Lake Ontario Preprint of paper. Atlantic Oceanographic Laboratory, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.
- #82BC FOULDS, J. B., 1972. Thesis Energetics of Vertical Migration in Mysis relicta Loven, 1862, University of Guelph, Ont.
- #94 McPHAIL, H., 1973. Data retransmission via Satellite, Field Year 1972. Canada Centre for Inland Waters, Burlington, Ontario.
- #97BL ELDER, F. C., 1973. Lake Ontario Meteorological Buoy Program 1972 - Field Report. Canada Centre for Inland Waters, Burlington, Ontario.
- #97BL TAYLOR, B., 1973. Meteorological Buoy Program 1972 - Statistical Summary of Met Buoy and Manual Measurements. Canada Centre for Inland Waters, Burlington, Ontario.
- #101BC STADELMANN, P., MOORE, J. G., and PICKETT, E., 1973. Primary Production in Relation to Light Conditions, Temperature Structure and Biomass Concentration at an Onshore and Offshore Station in Lake Ontario. Study for IFYGL. Great Lakes Biolimnology Laboratory, Fisheries and Marine Service, Canada Centre for Inland Waters, Burlington, Ontario.

- #107BL SHAW, R. W. and WHELPDALE, D. M., 1973. Sulphate Deposition by Precipitation into Lake Ontario. Preprint for Water, Air and Soil Pollution 2 (1973) pages 125-128. D. Reidel Publishing Company, Dordrecht, Holland. Atmospheric Environment Service, Downsview, Ontario.
- #116TW LOIJENS, H. S. and GRASTY, R. L., 1973. Airborne Measurement of Snow-Water Equivalent Using Natural Gamma Radiation over Southern Ontario, 1972-1973. Inland Waters Directorate, Ottawa, Ontario.

RELATED PUBLICATIONS

- CHRISTIE, W. J., 1972. Lake Ontario: Effects of Exploitation, Introductions, and Eutrophication on the Salmonid Community. Paper from the Proceedings of the SCOL Symposium. Ontario Ministry of Natural Resources, Ontario.
- CHRISTIE, W. J., 1973. A Review of the Changes in the Fish Species Composition of Lake Ontario. Technical Report No. 23. Ontario Ministry of Natural Resources, Ontario.
- CSANADY, G. T., 1972. Geostrophic Drag, Head and Mass Transfer Coefficients for the Diabatic Ekman Layer. Reprint from Journal of Atmospheric Sciences Vol. 29, No. 3, April 1973. University of Guelph, Ontario.
- FERGUSON, H. L. 1968. A Preliminary Estimate of the Ice-Season Energy Balance for the Niagara River. Reprint of Bulletin of IASH XIII Année No. 3, 1968. Atmospheric Environment Service, Downsview, Ontario.
- KENNEY, B. C., 1973. The Physical Effects of Waste Heat Input to the Great Lakes. Scientific Series No. 28. Canada Centre for Inland Waters, Burlington, Ontario.
- ONGLEY, E.D., Sediment Discharge from Canadian Basins into Lake Ontario. Preprint for the Canadian Journal of Earth Sciences. Queen's University, Kingston, Ontario.
- PHILLIPS, D. W. and McCULLOCH, J.A.W., 1972. The Climate of the Lakes Basin. Atmospheric Environment Service, Downsview, Ontario.
- TAYLOR, P. A., 1969. Numerical Models of Airflow above Lake Ontario September 1968, May 1969. Department of Mathematics, University of Toronto.

UNITED STATES

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COMMENTS BY THE U.S. DIRECTOR

This issue covers IFYGL activities from July 1 to September 30, 1973 (fig. 1). Some reports on events in October and November are included.

We have been notified of some changes relating to the IAGLR 17th Annual Conference, August 12-14, 1974, at McMaster University, which will influence our Second IFYGL Symposium. As now planned, presentation of IFYGL papers will be integrated with the remainder of the conference program. Abstracts of not more than two pages should be submitted to Dr. G.K. Rodgers, CCIW, by April 1, 1974. Completed manuscripts and illustrations for the Proceedings must be handed in at the conference.

Major emphasis continues to be placed on data management activities. As of November 1973, the following data sets are available from CEDDA upon request:

- The Physical Data Collection System (PDCS) Provisional Data Base for July 1972.
- Provisional data from 40 ship cruises on a 1-s cycle.
- Provisional rawinsonde data for one 6-day period.

With reference to the PDCS Data Base, we regret that figure 2 in IFYGL Bulletin No. 8, showing the PDCS data processing schedule, was incomplete. We therefore reproduce in this issue in figure 2 that schedule with proper labels added.

Meetings were held by the Energy Balance and Terrestrial Water Balance Panels during the quarter. In a preliminary discussion, a draft outline and modus operandi for preparing an IFYGL Scientific Report on the Terrestrial Water Balance were considered. The Joint Management Team will take further action to define publication procedures for the IFYGL Scientific Report series.

Plans have matured for the half-day IFYGL Symposium to be held in conjunction with the Spring Meeting of the AGU/AMS, April 8-12, 1974, in Washington, D.C. A Proceedings of this Symposium is planned to be published as a special issue of the IFYGL Bulletin in mid-1974. This program of invited papers is shown on the next page.

SYMPOSIUM

INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES (IFYGL)

PROGRAM

Chairman: W.J. Drescher

An Introduction to IFYGL
T. Lloyd Richards

Scientific Overview
Eugene J. Aubert

Terrestrial Water Budget
D.F. Witherspoon and B.G. DeCooke

Precipitation - Hurricane Agnes
James Wilson and David Pollock

Lake Meteorology - Atmospheric Water Balance
E.M. Rasmusson and J.A.W. McCulloch

Atmospheric Boundary Layer
Floyd C. Elder and Joshua Holland

Energy Balance
Arthur Pinsak and G. Keith Rodgers

Water Movement
E.B. Bennett and James Saylor

Internal Waves
Clifford H. Mortimer and F.M. Boyce

Biology and Chemistry
Nelson Thomas and Nelson Watson

Fisheries
W. Jack Christie and Joseph Kutkuhn

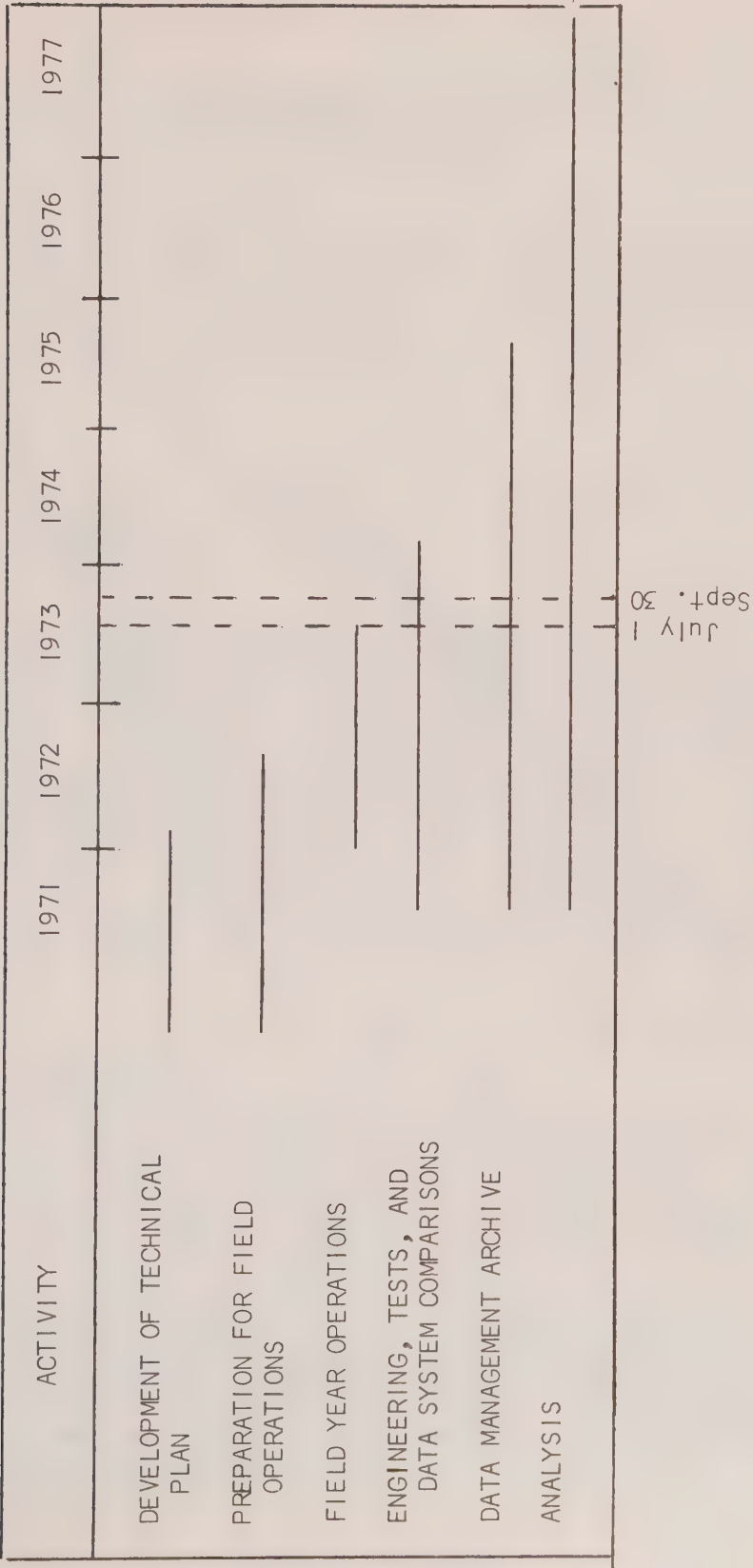


Figure 1.--U.S. IFYGL schedule.

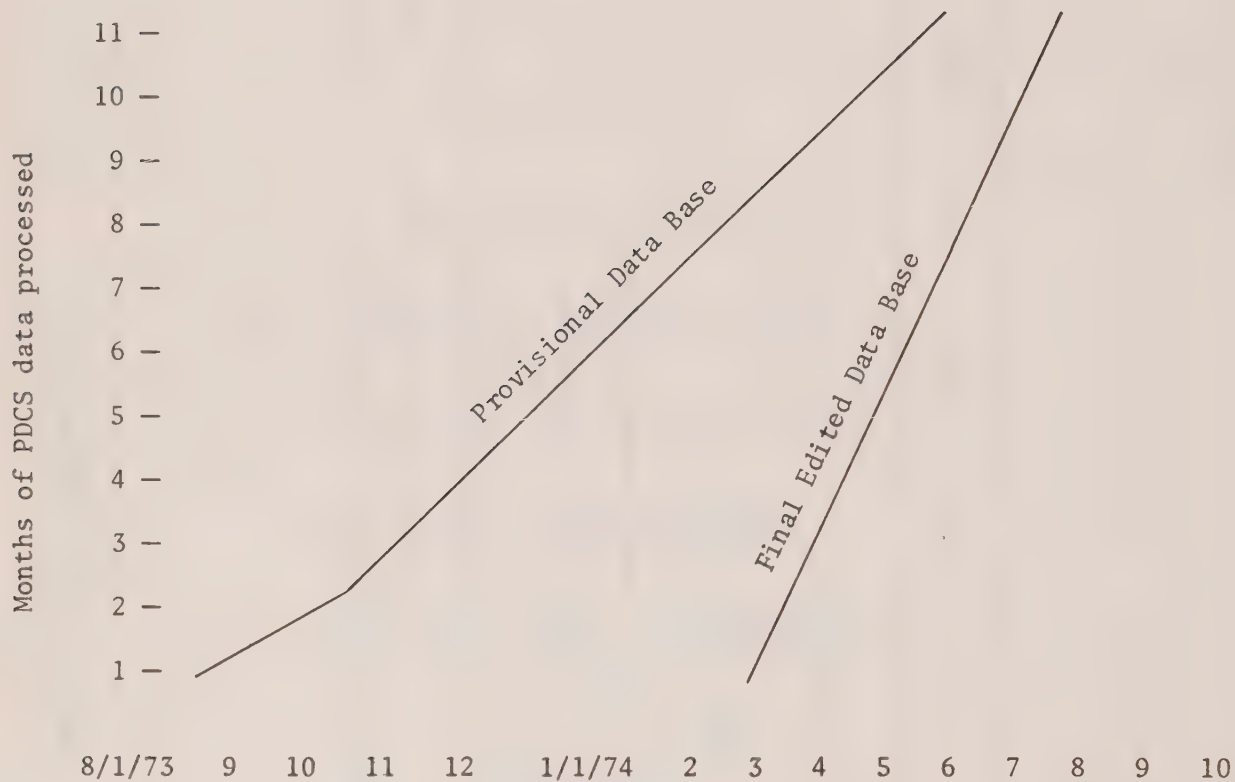


Figure 2.--Processing schedule for PDCS data base.

U.S. SCIENTIFIC PROGRAM

Based upon reports requested by the U.S. IFYGL Project Office, the progress from July 1 through September 30, 1973, is presented for each of the U.S. IFYGL tasks. Some reports cover work done in October 1973.

Project area status reports follow the task reports.

Tasks

1. *Phosphorus Release and Uptake by Lake Ontario Sediments*

Principal Investigators: D.E. Armstrong and R.F. Harris - University of Wisconsin

Preparations were completed for a sampling trip on Lake Ontario in October 1973, with the principal objective of obtaining sediment samples for immediate separation of interstitial water on the ship and subsequent analysis of interstitial phosphorus. As part of these preparations, the technique for separating interstitial water from sediments *in situ* was evaluated under various experimental conditions to determine possible effects of the technique on interstitial inorganic phosphorus values. The parameters included pressure, temperature, exclusion of oxygen, and time. Oxygen exclusion, time, and temperature were found to be critical. Evaluation of experimental results of this and other phases of the research task was continued and will be published.

2. *Net Radiation*

Principal Investigator: M.A. Atwater - CEM

Computations of the radiative fluxes at the surface have been completed for the entire Field Year and were included in the revised figures submitted to the IFYGL Project Office after the last quarterly report.

The basic program was modified to compute radiative heating rates, as an option, and to store these rates on tape. A program is now being checked out to average these rates over 3-hr intervals, as requested by E. Rasmusson (of CEDDA). Radiosonde data were added to the basic data sample for October and November 1972, and the radiative heating rates will be computed soon for the period October 1 to December 10, 1972, and 3-hr averages stored on punch cards.

No radiation data have been received from the IFYGL Data Center for comparison with computed values. These data should be available shortly.

A computer program was written and checked out to define periods of low visibility. Visibility and present weather as observed at the nine land stations and from the *Researcher* and *Advance II*, together with average visibilities, have been listed for all hours when critical visibility criteria were exceeded. Using this program and the data from all cruises by the two ships, all known episodes of low visibility from May 1, 1972, through November 1973, have been identified. The cloud summary data used in earlier radiation computations during episodes of low visibility have been tabulated, and synoptic conditions reviewed. Analysis revealed the need for selectively introducing a fog layer into more refined radiation computations. A fog routine that tests the basic data will be developed for this purpose.

Pertinent literature on, and various approaches for, diagnosing cloudiness above overcast low clouds were reviewed and evaluated in terms of their applicability to this study. Development of a diagnostic procedure is planned, which will include the use of a combination of persistence of previous analyses (for short periods) and inference of cloud amount from moisture and other information derived from radiosonde observations at Buffalo.

Satellite pictures have not yet been received, which has delayed an evaluation of their applicability to the selective revision of cloud amount.

3. *RFF/DC-6 Boundary Layer Fluxes*

Principal Investigator: B.R. Bean - ERL/NOAA

No report.

4. *Nitrogen Fixation*

Principal Investigator: R. Burris - University of Wisconsin

No report.

5. *Profile Mast and Tower Program*

Principal Investigator: J.A. Businger - University of Washington

No report.

6. *Status of Lake Ontario Fish Populations*

Principal Investigator: J.F. Carr - Great Lakes Fisheries Laboratory

No report.

7. *Material Balance of Lake Ontario*

Principal Investigator: D.J. Casey - EPA

No report.

8. *Runoff*

Principal Investigator: L.T. Schutze - U.S. Army Corps of Engineers

First-cut estimates of monthly runoff from the Canada basin are being prepared in Canada.

During the next quarter, first-cut estimates will be completed of monthly runoff from United States and Canadian land areas for April 1972 through March 1973. More refined estimates of runoff during the Field Year will be furnished by other investigators. No further work on this task after December 1973 is planned.

9. *Evaporation (Lake-Land)*

Principal Investigator: L.T. Schutze - U.S. Army Corps of Engineers

No progress was made during this quarter.

Plans are to complete first-cut estimates of monthly evaporation during next quarter for April 1972 through March 1973. As more refined data become available from other investigators, evaporation during the Field Year will be determined by the water budget method.

10. *Simulation Studies and Analyses Associated With the Terrestrial Water Balance*

Principal Investigator: B.G. DeCooke - U.S. Army Corps of Engineers

Activity has not begun.

11. *Land Precipitation Data Analysis*

Principal Investigators: L.T. Schutze and R. Wilshaw - U.S. Army Corps of Engineers

No progress made during this quarter.

We intend to begin investigation of methods to estimate weekly and monthly precipitation from index stations. We also plan to use daily precipitation estimates over land in the U.S. basin for 1972 furnished by F.H. Quinn, LSC.

12. *Transport Processes Within the Rochester Embayment of Lake Ontario*

Principal Investigator: W.H. Diment - University of Rochester

No report.

13. *Soil Moisture and Snow Hydrology*

Principal Investigator: W.N. Embree - U.S. Geological Survey

Work continues on the problem of computing monthly changes in soil moisture from the neutron-log data. Preliminary results and the method of analysis are being reviewed.

Analytical methods are being formulated for using soil moisture and snow data in predicting runoff.

14. *Boundary Layer Structure and Mesoscale Circulation*

Principal Investigator: M.A. Estoque - University of Miami

See Task 15 below.

15. *Mesoscale Simulation Studies*

Principal Investigator: M.A. Estoque - University of Miami

Han Wei Lai and James Gross spent most of the period at the NCAR Computer Facility in Boulder writing and debugging their computer programs. Mr. Lai is working on a two-dimensional, vertical cross-section model, while Mr. Gross is working on a three-dimensional model. The computer programs for integrating these two models are almost complete.

16. *Lake Level Transfer Across Large Lake*

Principal Investigator: C.B. Feldscher - LSC/NOAA

As a basis for analyzing the effects of wind and barometric pressure, periods of calm weather were selected, and comparisons of the water levels as recorded by United States and Canadian gages on Lake Ontario were begun. Analysis of other methods of carrying out our task was continued.

17. *Nearshore Ice Formation, Growth, and Decay*

Principal Investigator: A. Pavlak - General Electric Company

Through A.P. Pinsak and the Energy Budget Panel Workshop, sources of supplemental data have been identified and contacted. The 1973-74 winter field program has been planned and will consist of time-lapse photography and several thermistor traverses from a boat or through the ice. A preliminary model has been formulated.

18. *Advection Term - Energy Balance*

Principal Investigator: J. Grumblatt - LSC/NOAA

No report.

19. *Occurrence and Transport of Nutrients and Hazardous Polluting Substances in the Genesee River Basin*

Principal Investigator: L.J. Hetling - New York State Department of Environmental Conservation

Water quality network:

The biweekly sampling of the water quality network is continuing on schedule, with the addition of sampling at the point of discharge of three syphons from the canal into a tributary of Allens Creek. Stream samples for analyses of heavy metals and pesticides were collected on August 8 and October 2. Sediment samples were collected on August 21 and October 8. The biweekly stream sampling will continue through December 1973. Data from the first 12 months of the collection period will be analyzed statistically during the next quarter. Comparisons will be made with existing data.

Point source discharge:

Intensive sampling was carried out as planned, except for one major change. When sampling began at Spring Brook, it was found that the major part of the creek had dried out. A 24-hr sampling program at the Lima Sewage Treatment Plant was substituted, which included 2-hr samples of raw sewage and plant effluent, and one downstream and one upstream sample every 6-hr.

Avon Creek was sampled between August 8 and 12, with 3 stations added to the regular 9 in order to include one reach of stream not

normally sampled and one tributary junction. The weather was dry during the 5 days. Fish Creek was sampled from August 13 to 18, with 7 stations added to the normal 11 to provide samples from three tributary junctions. During this period, there was 1 day of heavy rain, which made it possible to obtain samples at the end of a dry period, during a heavy rain, and when the stream returned to lower flows.

At the end of the intensive period, normal sampling was resumed. By that time, precipitation had been sufficient for flow to return along the entire length of Spring Brook. The biweekly program will continue through the end of October, after which samples will be taken every 4 to 6 weeks through the end of March 1974. After the end of October, a dye study will be made to determine the travel time on the reach of each stream, and 24-hr sampling will be carried out at the Holcomb Sewage Treatment Plant and the Harper Trailer Park Sewage Treatment Plant.

20. *Boundary Layer Flux Synthesis*

Principal Investigator: J.A. Almazan - CEDDA/NOAA

Analysis continued of the Canadian and United States pre-provisional meteorological buoy data for July 7 through 21, 1972. An objective analysis scheme, developed by J. Jalickee, CEDDA, in which orthogonal polynomials are used, is being tested on the data. Briefly stated, the technique consists of the following:

The merged data from the United States and Canadian buoys, towers, and, in certain cases, land stations are first fitted to orthogonal polynomials defined by the latitude-longitude coordinates of the sensor and the time of observation. The coefficients are then determined. Neither regular spacing nor periodic observations are required. With the coefficients and the polynomials, estimates of the meteorological field and the respective confidence intervals can be obtained for any point within the space-time region of the data.

Derived fields can be obtained with this technique. For example, the lake-area average is calculated by a simple combination of analytical and numerical integrations by means of Green's theorem; a series of points joined with straight lines delineates the perimeter of the specified area.

Other derived fields, such as space-time derivatives, can be calculated since the estimated fields are analytic.

The work done during this quarter includes:

- (a) Maps of area-averaged values of the measured meteorological data.

- (b) Derived estimates of momentum, heat, and water vapor surface fluxes.
- (c) Vorticity and divergence fields.
- (d) Lateral and longitudinal wind component fields.

The estimated fields have been compared with the observed fields and the prevailing synoptic patterns. The agreement is good, and the "confidence maps" show encouraging results. The method appears quite effective for this type of analysis of surface data and for obtaining area-time averages of the meteorological fields and surface flux estimates.

21. *Hazardous Material Flow*

Principal Investigator: T. Davies - EPA

No report.

22. *Remote Measurement of Chlorophyll With Lidar Fluorescent System*

Principal Investigator: H.H. Kim - NASA

No report.

23. *Inflow/Outflow Term - Terrestrial Water Budget*

Principal Investigator: I.M. Korkigian - U.S. Army Corps of Engineers

This task has been completed, and the final report submitted to the U.S. IFYGL Data Center.

24. *Use of an Unsteady-State Flow Model To Compute Continuous Flow*

Principal Investigator: I.M. Korkigian - U.S. Army Corps of Engineers

Simultaneous measurements of discharge have been made at two hydraulic sections on the St. Clair River to provide a base data for developing the unsteady-state flow model. As noted in Bulletin No. 8, the St. Clair River's proximity to Detroit makes it more advantageous to measure than the Niagara or St. Lawrence. The results will be used to construct the unsteady-state model. With the results of past measurements on the St. Lawrence River, the model will be adapted for use in computing Lake Ontario's outflow.

25. *Radiant Power, Temperature, and Water Vapor Profiles Over Lake Ontario*

Principal Investigator: P.M. Kuhn - ERL/NOAA

Work completed.

26. *Algal Nutrient Availability and Limitation in Lake Ontario*

Principal Investigator: G.F. Lee¹ - Texas A & M University

Studies of nitrogen mineralization on samples collected in the spring of 1973 were completed in mid-August, and compilation of data from all work on nitrogen is almost complete. Two sets of New York rain-gage water samples obtained in May and June 1973 have been processed for estimating phosphorus availability.

27. *Wave Studies*

Principal Investigator: P.C. Liu - LSC/NOAA

No report.

28. *Cloud Climatology*

Principal Investigator: W.A. Lyons - University of Wisconsin,
Milwaukee

Field data collection continued through mid-July 1973. A truck was dispatched from Milwaukee to retrieve the four cameras and two Kipp & Zonen solarimeters, all of which were in good condition. Acquisition of data with the two solarimeters was 90 to 95 percent successful. A summary of days covered by these data is available. After repair in late winter, the cameras performed with greater than 75 percent efficiency. Photographic quality was consistently good.

We have continued to receive extremely exciting ERTS-1 and Data Acquisition and Processing Program (DAPP) high-resolution cloud images over the basin. These will ultimately be integrated into the final climatological analysis. In the interim, several publications have been issued and conference papers given or scheduled that give new insights into the physical mechanisms affecting clouds over the Great Lakes. Views of winter snowsquall mesosystems have proven most spectacular. "Communication" between lakes has been found most dramatic,

¹

N. Sridharan and W. Cowen are no longer connected with this task.

i.e., destabilization of air flowing over one lake causes dramatically enhanced convection if the airstream crosses another lake downwind.

29. *Zooplankton Production in Lake Ontario as Influenced by Environmental Perturbations*

Principal Investigator: D.C. McNaught - State University of New York at Albany

No report.

30. *Change in Lake Storage Term - Terrestrial Water Budget*

Principal Investigator: R. Wilshaw - U.S. Army Corps of Engineers

There was no progress during this quarter. It is anticipated that computer programming and data processing will be completed by the end of 1973. Results should be available shortly thereafter.

31. *Soil Moisture*

Principal Investigator: L.T. Schutze - U.S. Army Corps of Engineers

Lack of manpower and complete data from other investigators on precipitation, evaporation, and runoff continue to delay the start of this project.

32. *Testing of COE (Corps of Engineers) Lake Levels Model*

Principal Investigator: E. Megerian - U.S. Army Corps of Engineers

No report.

33. *Nearshore Study of Eastern Lake Ontario*

Principal Investigator: R.B. Moore - State University of New York at Oswego

No report.

34. *Internal Waves - Transects Program - Interpretation of Whole-Basin Oscillations*

Principal Investigator: C.H. Mortimer - University of Wisconsin, Milwaukee

The depth distribution of temperature has been plotted from undulator tapes and bathythermograph slides for 120 transects covering two sections of Lake Ontario during our three cruises. (See table 1.)

Table 1.--Transects used for initial planning of temperature depth distribution

Cruise date (1972)	Researcher (undulator)		Advance II (bathythermograph)	
	No. of transects	Section	No. of transects	Section
July 24-28	21	Braddock Point	16	Oswego to
August 7-11	26	to	17	Prince Edward
October 2-6	18	Presqu'ile	22	Island

This initial plot is subject to calibration check. Also, before these transects can be entered into the data bank in final form, comparison (now in progress) with other data from the following sources will be necessary:

- (a) Temperature distribution data from the Coastal Chains at the Canadian and United States ends of the sections. These data have already been obtained from G.T. Csanady and J.T. Scott.
- (b) Hourly temperature readings (already received) at the Rochester City Water Intake.
- (c) Temperature distribution found in or near our transect sections during the heat budget cruises immediately preceding and following our cruises.
- (d) Wind, water temperature, and current data from the buoys and in-lake towers on or near our sections for intervals that overlap our cruises by at least 4 days before beginning date and 3 days after ending date of the cruises.

35. *Pontoporeia affinis and Other Benthos in Lake Ontario*

Principal Investigator: S.C. Mosley - University of Michigan

No report.

36. *Pan Evaporation Project*

Principal Investigator: C.N. Hoffeditz² - NWS/NOAA

In July 1973, all instruments and evaporation pans were removed and sites restored to their original condition. Data reduction, key punching, and data consistency checks are proceeding.

Analysis of the data from the U.S. stations is behind schedule because dew-point and radiation data have not been received from the collocated Physical Data Collection System (PDCS). Receipt of the last 4 months (March, April, May, and June) of data from the Hamilton 4NE evaporation station (collocated with PDCS-Rochester Control Center) is expected shortly.

Techniques are being developed to correct the long-wave radiation data recorded at the Ft. Niagara evaporation station. These data, in conjunction with the incoming short-wave radiation data, will be used to check the integrating ability of the X-3 pan. Other radiation data will also be used as they become available.

When the PDCS dew-point data are received, shallow-lake evaporation computations will be made by the proposed methods. With receipt of the change in energy storage and advected energy data from the Energy Budget Group, corrections will be made to obtain Lake Ontario evaporation estimates.

37. *Simulation Studies and Other Analyses Associated With U.S. Water Movements Projects*

Principal Investigators: J.P. Pandolfo and C.A. Jacobs - CEM

The second in a series of simulations of a cold front passage over Lake Ontario has been completed, and the results are contained in a report entitled "The Numerical Simulation of the Response of Lake Ontario to the Passage of a Typical March Cold Front", dated July 1973 and sent to the U.S. IFYGL Project Office. The objective of this experiment was discussed in IFYGL Bulletin No. 8.

Our future plans are directed toward preparing several three-dimensional simulations using different versions (free surface and filtered) of the model to simulate selected IFYGL periods. We hope that at least one of these periods will be used by several modelers, and are

²C.N. Hoffeditz replaced T.J. Nordenson as Principal Investigator on July 1, 1973.

encouraged in this regard by J. Simons of CCIW, who has prepared a data set for model input and verification for several days, centered on August 9, 1972.

38. *Structure of Turbulence*

Principal Investigator: H.A. Panofsky - Pennsylvania State University

As a result of more accurate wind directions made available by Mark Donelan, CCIW, the dependence of coherence on angle between wind direction and anemometer line, and on stability, has now become quite clear. Isopleths on a diagram with these coordinates can be drawn quite easily. Most of the data analyzed had been recorded on magnetic tape. An extra run was analyzed on the basis of strip-chart records, and the coherence determined from it was in good agreement with that expected from the isopleths.

Diagonal coherences (2 m at one tower and 7 m at the other) were analyzed and were found not to vary significantly from horizontal coherences. No differences could be detected between coherence along diagonals in the direction of and opposed to the wind shear.

Temperature and wind data have been received from Mark Donelan, and true Richardson numbers are now being computed. Based on these rather than on air-water differences, comparisons with overland measurements are possible.

39. *Airborne Snow Reconnaissance*

Principal Investigator: E.L. Peck - NWS/NOAA

Ground measurements of snow cover made on dates close to those on which aerial surveys were conducted have been collected for correlation with airborne estimates for two lines (SYRC 140 and 150) in the area where the University of New York conducted its special snow cover measurement program. Because of sparse snow cover, however, the ground reports do not add much information for the days when flights were made over the area.

If the results of the aerial survey program are to have maximum value for the overall IFYGL program, the data should be coordinated with those of other programs to develop as consistent and complete knowledge of the snow cover as possible. This will be limited because of the sparse and variable snow cover that occurred during the study year.

A paper on "Lake Ontario Snowfall Observational Network for Calibrating Radar Measurements" by E.L. Peck, L.W. Larsen, and J.W. Wilson has been submitted for preprinting for the International Symposium on Snow and Ice to be held in Monterey, Calif., December 2 to 6, 1973. Preprint copies will be sent to the IFYGL Project Office when they become available.

Interim Report No. 4 was published in May 1973 documenting ground survey snow water equivalent measurements made at calibration lines on February 28 - March 1, March 9, and March 28, 1973.

A draft of Interim Report No. 5, "Water Equivalent From Airborne Survey Gamma Data", has been prepared by EG & G, Inc. It has been reviewed by NWS and discussed in detail with EG & G officials during a visit by E.L. Peck and Vern Bissell in Las Vegas from September 26 to 28, 1973. Preliminary results indicate good agreement among aerial survey estimates and the ground water equivalent for the calibration flight lines.

After publication of Interim Report No. 5, what remains is the preparation of a final report summarizing the work on this task and its results.

40. *Optical Properties of Lake Ontario*

Principal Investigator: K.R. Piech - Calspan Corporation

All surface and aerial data have been incorporated into a matrix format that will allow rapid recall and display of temporal, areal, and intersensor comparisons. The aerial data have been integrated into the format, and additional formats have been developed for the surface data.

A preliminary decision has been made to place the original surface data, which are in a graphical form of parameter value versus depth, on microfiche for transmission to the IFYGL Data Center. This we hope to do during the next reporting period.

Chlorophyll data are being obtained from CCIW through the cooperation of Floyd Elder and Keith Thomson. Both surface (1 m) and integrated sample values will be matrixed and compared with the optical parameters, especially the aerial blue/green reflectance ratios. These comparisons should be completed during the next quarter.

41. *Storage Term - Energy Balance Program*

Principal Investigator: A.P. Pinsak - LSC/NOAA

No report.

42. *Sensible and Latent Heat Flux*

Principal Investigator: A.P. Pinsak - LSC/NOAA

No report.

43. *Thermal Characteristics of Lake Ontario and Advection Within the Lake*

Principal Investigator: A.P. Pinsak - LSC/NOAA

No report.

44. *Oswego Harbor Studies*

Principal Investigator: G.L. Bell - LSC/NOAA

Between May 1 and November 10, 1972, 33 cruises were conducted, covering the 50 stations in and adjacent to Oswego Harbor, N.Y., shown in figure 3. The cruise schedule is given in table 2.

Of the 1,683 water samples recovered, 755 were analyzed for major ions. The remaining samples were analyzed aboard the *Shenehon* for pH, Eh, alkalinity, dissolved oxygen, and specific conductivity. Not all tests were made on every cruise. Conductivity was determined on 31 cruises and proved to be a very good parameter for tracking the harbor effluent. A total of 136 bottom samples were recovered by a Shipek sampler; 67 were described and analyzed for pH, Eh, and volatiles; 59 for oil and grease, and 58 for COD. About half of the samples contained insufficient volume for analysis.

Data reduction and listings for bathythermograph, percent transparency, suspended sediment (filtering) and total coliform are complete. A limnological listing showing all chemical parameters will be generated.

The meteorological data from the *Shenehon* have been translated to cards and preliminary magnetic tapes. Some data gaps will be supplemented with data from teletype printouts. These data will not be available until the first part of 1974.

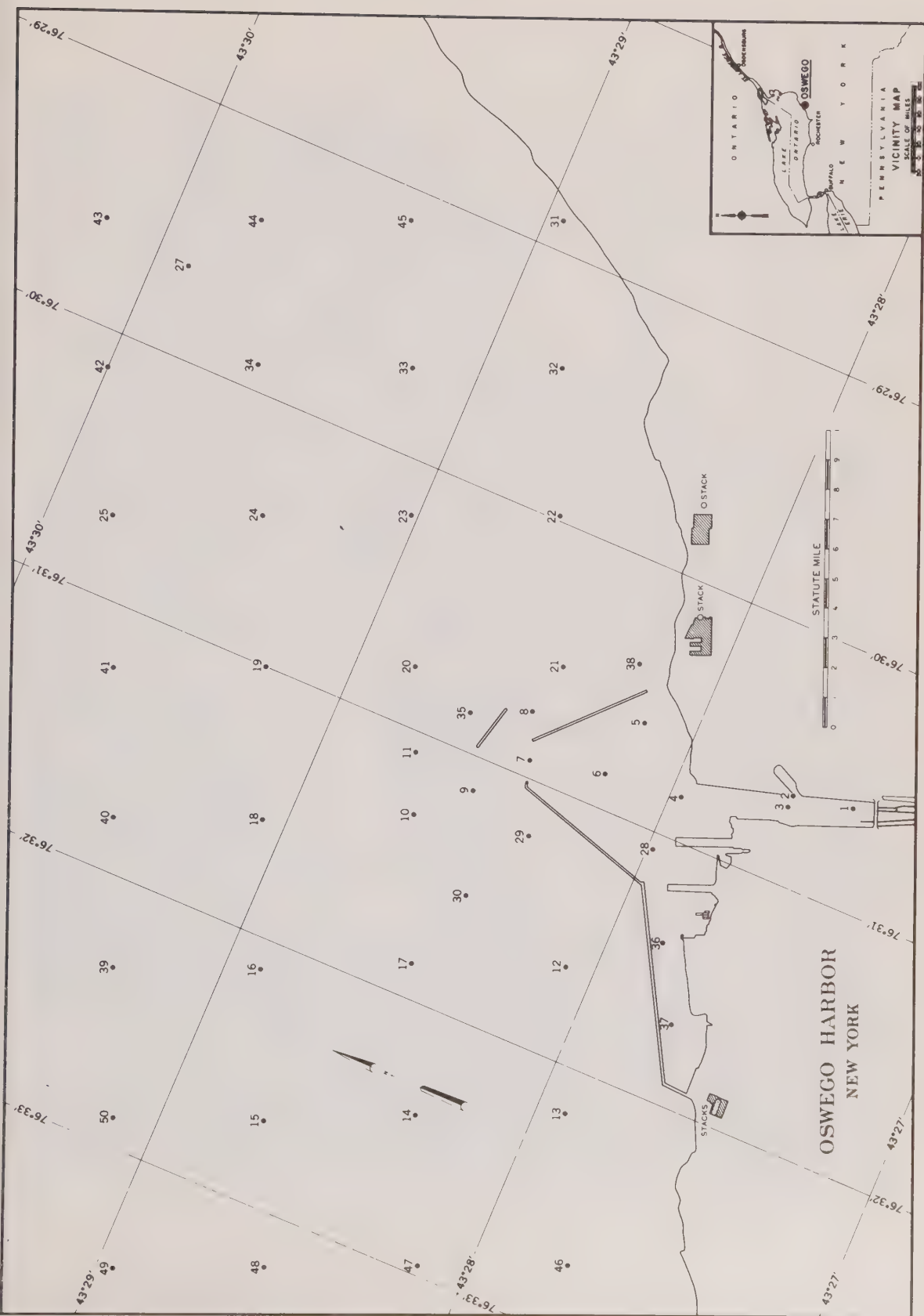


Figure 3. ---Cruise stations for Oswego Harbor Studies

Table 2.--Lake Survey Center cruise schedule, R/V Shenehon

Cruise No.	Date (1972)	Cruise No.	Date (1972)
1	May 1	18	August 22
2	May 2	19	August 23
3	May 3	20	August 24
4	May 4	21	August 25
5	May 5	22	October 17
6	June 13	23	October 19
7	June 14	24	October 20
8	June 15	25	October 21
9	June 16	26	October 24
10	June 17	27	October 25
11	June 19	28	October 26
12	June 20	29	October 27
13	June 21	30	November 7
14	June 22	31	November 8
15	June 23	32	November 9
16	August 19	33	November 10
17	August 21		

45. *Mapping of Standing Water and Terrain Conditions With Remote Sensor Data*

Principal Investigator: F.C. Polcyn - University of Michigan

Most of the high-speed processing for the Lake Ontario basin has been completed, and the parallel digital processing of the East and Middle Oakville basin has begun. All ERTS data processing is on schedule.

The ERTS data tapes that had been converted to analog form earlier were processed during this quarter with the Environmental Research Institute of Michigan-Spectral Analysis and Recognition Computer (ERIM-SPARC) system, a special-purpose likelihood-ratio image classifier. The speed of this system is such that ERTS data comprising portions of eight frames (32,000 mi²) were processed at the rate of 1 1/2 hr per target. First the data tapes were edited for an approximate delineation of the Lake Ontario drainage basin. (See figure 4.)



Figure 4.---Approximate delineation of the Lake Ontario drainage basin from ERTS data.

Eight targets, representing eight hydrologically significant terrain classes, were printed out. These were then mosaicked to produce a single image of each terrain class, as shown in the sample in figure 5. Simultaneously with the printing of each terrain class, analog counts were recorded digitally for each class. Since the total number of counts for the entire basin had been established previously, the percentage of the basin occupied by each class was obtained.

In producing these terrain thematic maps, the main problem was how to extend a single recognition signature for a single terrain type to a number of ERTS frames, not all of which were collected on the same day. Two types of preprocessing were used in solving this problem: dark-level subtraction and ratios of ERTS bands. A discrete level that represented the signal level for the darkest object in each ERTS frame was subtracted from each pixel, or scene element. This dark-level value was slightly different for each frame and was assumed to represent the d.c. effect of additive atmospheric path radiance and scanner calibration differences from one day to the next. The ratio of two ERTS bands provided recognition criteria based on the relative spectral difference that occurs between each band, not on the absolute signal levels.

Parallel digital processing is being coupled with the high-speed processing for better understanding and validation of the recognition results from the ERIM-SPARC system (fig. 6). A small representative watershed (81 mi²) was selected for the accuracy test. The digital results are expected to provide empirical bounds for the classification accuracy of the thematic maps for the entire basin. We also hope that the results will contribute to the development of a mathematical model of this watershed by the Ontario Ministry of the Environment.

46. *Remote Sensing Program for the Determination of Cladophora Distribution*

Principal Investigators: F.C. Polcyn and C.T. Wezernak - University of Michigan

No report.

47. *Remote Sensing Study of Suspended Inputs Into Lake Ontario*

Principal Investigators: F.C. Polcyn and C.T. Wezernak - University of Michigan


No report.

48. *Island-Land Precipitation Data Analysis*

Principal Investigator: F.H. Quinn - LSC/NOAA

No report.





SURFACE WATER MAP

ONTARIO BASIN AUGUST 1972

Figure 5.--Sample mosaic based on ERTS data.

ERTS—IFYGL LAKE ONTARIO PROJECT

DATA PROCESSING

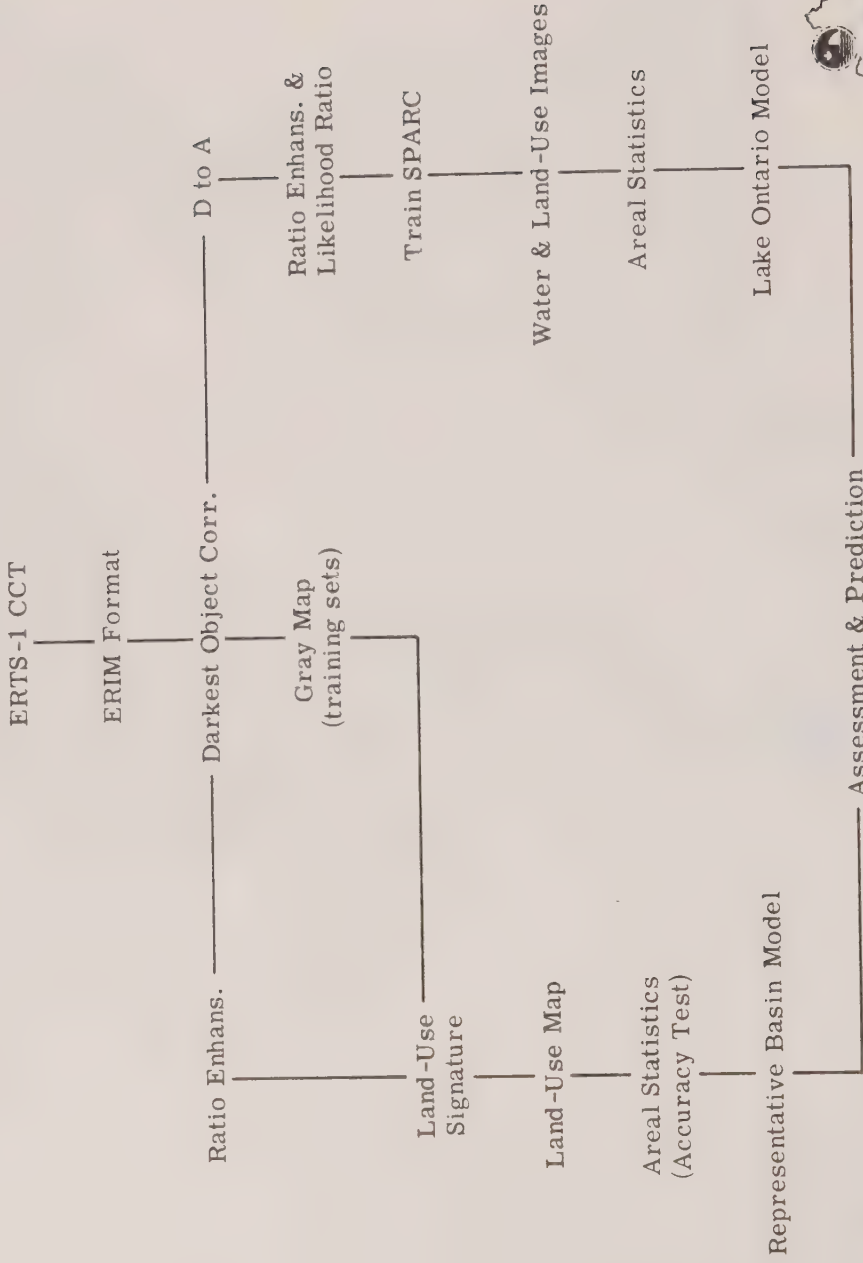


Figure 6.--ERTS data processing structure.

49. *Lake Circulation, Including Internal Waves and Storm Surges*

Principal Investigator: D.B. Rao - University of Wisconsin, Milwaukee

No report.

50. *Atmospheric Water Balance*

Principal Investigator: E.M. Rasmusson - CEDDA/NOAA

Data from 25 rawinsonde flights became available during the quarter. The program that fits the measured variables (T , q , u , v) by means of orthogonal functions generated from the independent variables (θ , λ , p^* , t) was tested on these soundings and gave reasonable results.

Two programs were completed: one for integrating and differentiating the orthogonal functions representing the basic variables with respect to time and/or space; the other for finding the area average of basic or derived variables for the "defined" IFYGL area.

Rawinsonde data for 6 days, from October 31 to November 5, will soon be available in meteorological form. Our first task will be to correct the errors that do not show up easily in the frequency domain, which had been checked for errors earlier.

Based on the analyzed fields, we will compare values at the actual balloon position with those directly over the stations in order to assess the relative importance of balloon drift.

Calculations for the mass budget will begin during the next quarter.

51. *Evaporation Synthesis*

Principal Investigator: E.M. Rasmusson - CEDDA/NOAA

An objective technique for the analysis of the buoy meteorological data used in the Evaporation Synthesis and Boundary Layer Flux Synthesis tasks has been developed. For further details, see report on Task 20.

52. *Groundwater Flux and Storage*

Principal Investigator: E.C. Rhodehamel - U.S. Geological Survey

The computation procedures for determining the monthly changes in groundwater storage (ΔS) have been further refined and used in two trial runs. The analytical methods for determining the groundwater flux and ΔS values are being documented.

53. *Spring Algal Blooms*

Principal Investigator: A. Robertson - IFYGL Project Office/NOAA

Analysis awaits availability of data.

54. *Ice Studies for Storage Term - Energy Balance*

Principal Investigator: F.H. Quinn - LSC/NOAA

No report.

55. *Lagrangian Current Observations*

Principal Investigator: J.H. Saylor - LSC/NOAA

No report.

56. *Circulation of Lake Ontario*

Principal Investigator: J.H. Saylor - LSC/NOAA

No report.

57. *Phytoplankton Nutrient Bioassays in the Great Lakes*

Principal Investigator: C. Schelske - University of Michigan

Task not activated.

58. *Runoff Term of Terrestrial Water Budget*

Principal Investigator: G.K. Schultz - U.S. Geological Survey

Work on this task is complete.

59. *Coastal Chain Program*

Principal Investigator: J.T. Scott - State University of New York
at Albany

The basic data report on the United States coastal chain program has been completed and mailed to the IFYGL Project Office. The data from the Canadian coastal chain have been plotted, and graphics are being prepared. Baroclinic geostrophic current patterns for all five buoy

lines have been calculated and will be drafted shortly. Data obtained from a brief study of the Rochester embayment have been analyzed, and results will be published as a technical data report during the next quarter. Preliminary analysis has begun of the EBT data we now have, but more data have to be obtained before further progress can be made.

Analysis during the next quarter will be focused on examining 5- to 10-day natural "events." A coherence study that includes all five coastal chains is being done in collaboration with G.T. Csanady, and a report on this study is expected to be completed by the end of the quarter or early next year.

Future plans include comparison of coastal chain data with buoy and tower data to determine the validity of long-term means of current and temperature from coastal chain data. EBT data will be combined with the coastal chain data to examine variation of the temperature structure in Lake Ontario. Water-level data, temperature data, and the V components of measured currents will be used for studying meanders in the "coastal jet."

60. *Analysis of Phytoplankton Composition and Abundance*

Principal Investigator: E.F. Stoermer - University of Michigan

No report.

61. *Clouds, Ice, and Surface Temperature*

Principal Investigator: A.E. Strong - NESS/NOAA

No report.

62. *Analysis and Model of the Impact of Discharges From the Niagara and Genesee Rivers on Nearshore Biology and Chemistry*

Principal Investigator: R.A. Sweeney - State University of New York
at Buffalo

All chemical analyses of sediment have been completed, including heavy metals in material collected by the State University College at Oswego in the Rochester-Stony Point nearshore zone. Analyses of biological material continues on schedule. Lack of water chemistry data on samples gathered in the nearshore zone has slowed work on the model, as well as evaluations of data from other phases of this task.

63. *NCAR/DRI - Buffalo Program*

Principal Investigator: J.W. Telford - Desert Research Institute,
University of Nevada

No report.

64. *Mathematical Modeling of Eutrophication of Large Lakes*

Principal Investigator: R.V. Thomann - Manhattan College

Main emphasis during the quarter was placed on structuring a 7-vertical-layer, 14-system model (LAKE 2). This model includes nutrient limitation, predation, and the carbon system. Sensitivity analysis and verification on the three-layer vertical model (LAKE 1) continued.

The LAKE 2 model is structured with four vertical layers, one representing the epilimnion, two the hypolimnion, and one the benthos. The model currently includes 12 interactive biological and chemical systems. The two remaining systems are temperature and a conservative tracer. The biological systems are phytoplankton and zooplankton biomass. The chemical systems include organic nitrogen, ammonia, nitrite, nitrate, phosphate, organic phosphorous, total inorganic carbon, alkalinity, organic carbon, and dissolved oxygen. The temperature system is driven by a boundary condition in the surface layer of the lake. The temperature of the various lower layers is computed internally, which drives the stratification and mixing phenomena of the lake. When the temperature of any two adjacent vertical layers are the same, the densities, therefore, being equal, the layers are then completely mixed. The conservative tracer system is used as an aid in analyzing the dispersion and transport phenomena.

Verification runs were made for temperature, establishing the dispersion transport regimes. Stratification and overturn, as illustrated in the baseline temperature data, compared well with the model-computed results. Preliminary runs were also made with all the systems in the LAKE 2 phytoplankton model.

Initial structuring of a 67-segment spatially (both horizontally and vertically) defined model was undertaken (LAKE 3). Plans for the next quarter include continuation of the preliminary runs of the LAKE 2 model and structuring of LAKE 3.

65. *Cladophora Nutrient Bioassay*

Principal Investigator: G.F. Lee³ - Texas A & M University

Inactive.

66. *Sediment Oxygen Demand*

Principal Investigator: N.A. Thomas - EPA

The results of the sediment oxygen demand studies have been tabulated and placed on a contour figure. A preliminary draft of a report should be available after the first of the year. The demand rates are quite consistent with the type of bottom found throughout the lake.

67. *Main Lake Macrobenthos*

Principal Investigator: N.A. Thomas - EPA

The bulk of the organisms have been mounted. Identification is proceeding and should be complete around January 1. Chemical analyses of the sediments are finished and will be correlated with the distribution of organisms.

68. *Exploration of Halogenated Hazardous Chemicals in Lake Ontario*⁴

Principal Investigator: G.F. Lee - Texas A & M University

Qualitative analysis of fish extracts for pesticides:

The pesticide fractions of Lake Ontario fish extracts were run on four gas chromatographic (GC) columns with electron capture detectors (³H or ⁶³Ni) to determine elution patterns for peak-matching identification of the extract components. GC columns and column conditions are listed in table 3.

The peak positions were measured from the leading edge of the solvent peak and converted to relative retention times (RRTs) by normalization, taking the retention time of p,p'-DDE as 100. This compound is one of the largest peaks of the chromatograms and is easily identified by comparison with the retention time of standard p,p'-DDE solutions.

³ W. Cowen is no longer a co-principal investigator on this task.

⁴ This task is being conducted in part at the University of Wisconsin

Table 3. --Gas chromatographic columns and conditions*

Stationary phase	1.5% OV-17/1.95% QF-1	2% OV-101/3% QF-1	1% QF-1	3% OV-17
Solid support	-----100/120 mesh Gas Chrom Q -----			
Column length (ft)	7	5	10	7
Column temperature (°C)	185	150	185	185
Detector temperature (°C)	210	190	210	210
Injector temperature (°C)	210	210	210	210
Carrier gas (N ₂) flow (ml/min)	15	12	36	24

* All columns are coiled glass tubes; inner diameter, 2 mm.

Data for peak comparison was obtained from reported values for the QF-1 and 1.5 percent OV-17/1.95 percent QF-1 columns and for all columns by repeated runs with single component and "cocktail" standard solutions. The standard deviation for the RRTs of known pesticides was typically around 1 percent of mean values. The literature values, calculated from peak position versus point of injection and normalized (aldrin = 1.000), were converted to appropriate values for comparison by considering observed solvent retention times and renormalizing (p,p'-DDE = 100). The converted literature RRTs agree quite well with those obtained from standards.

The RRTs thus compiled for each column were compared with peaks observed from the chromatograms of samples on that column. The extract chromatograms for each sample on the different columns were then compared for agreement in terms of RRT values consistent with the relative peak heights. The scheme for identifying the pesticides is shown in table 4. These identifications should be considered tentative until confirmed by gas chromatography/mass spectroscopic data.

Quantitative analysis of fish extracts for pesticides:

The extracts are being chromatographed a second time on those columns giving minimal peak overlap, and the peak areas are being compared with standards through the use of a Disc Instruments, Inc., integrator.

Other extracts and fractions:

A few of the other fractions and extracts from fish and other segments of the Lake Ontario ecosystem were screened by GC on some of the columns mentioned above. Chromatograms show plankton, water, sediment, and *Cladophora* pesticide fractions to contain easily detectable amounts of chlorinated hydrocarbons. The PCB fraction of fish extracts show many large peaks with a complex elution pattern, but the phthalate ester fraction shows only a few weak peaks.

69. *Basin Precipitation - Land and Lake*

Principal Investigator: J.W. Wilson - CEM

The report on the comparison of rainfall measurements by radar and gages during Hurricane Agnes has been completed and submitted to the Journal of Applied Meteorology.

Considerable progress was made in reducing the data from the Oswego Snow Mesonet and comparing water equivalent measurements with those

Table 4.--Components identified in pesticide fraction of fish extracts from Lake Ontario

Location	Hamilton			Olcott			Rochester			Mexico Bay			Galloo-Stoney			Prince Edward Pt.		
Species*	S	A	SS	S	A	SS	S	A	SS	A	SS	SS	S	A	SS	S	A	SS
<u>Pesticide</u>																		
α BHC			?	X	X	X	X	X	X	X	X	X	X			X	X	X
β BHC			?	X		?	X		?									
Lindane				X	X	X	X	X	X	X	X	X				X		X
Heptachlor							?											
Aldrin				?														
O,p'-DDE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
p,p'-DDE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dieldrin	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Endrin						?				X	X	X				X	X	X
O,p'-DDD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
p,p'-DDD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
O,p'-DDT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
p,p'-DDT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

*Species designations: S = smelt, A = alewife, SS = slimy sculpin, and TSS = three-spined stickleback

estimated from radar. The data from the snow network have been particularly valuable in establishing procedures for using the radar data to estimate snowfall during the Field Year. The radar estimates have to be adjusted upward; the magnitude of the adjustment depends on the type of snowstorm and distance from the radar. A paper on the results of the snow study is being prepared for presentation at the Symposium on Advanced Concepts and Techniques in the Study of Snow and Ice Resources to be held December 1973, in Monterey, Calif.

Work was begun to derive rainfall estimates over the lake from 16-mm pictures of the PPI scope during periods when echo intensity data were not successfully collected on magnetic tape. The echo contours for approximately 500 pictures have been traced onto charts and sent to the National Severe Storms Laboratory (NSSL) for planimetry. To date, NSSL has returned 150 of these charts complete with the areal measurements for each contour.

The task of entering daily gage measured rainfall totals onto Lake Ontario watershed maps was also begun. CEM is entering the data for the United States stations, and AES in Canada is entering the data for the Canadian stations.

A computer program was completed that determines daily precipitation totals from the magnetic tapes containing radar-derived hourly precipitation totals. The daily totals are determined for a grid square 6.8 mi on a side and printed on a scale that can be directly overlayed onto the watershed maps containing the gage totals. Production runs with this program are now in progress.

0. *Evaluation of ERTS Data for Certain Hydrological Uses*

Principal Investigators: D.R. Wiesnet and D.F. McGinnis - NESS/NOAA

The soil-moisture studies continue to progress slowly. Examination of the computer printouts of ERTS-1 imagery over the New York test sites has not revealed the effect of soil moisture on reflectance in the Scipio, N. Y., area.

Excellent correlation of the 13.4 and 4.99 GHz data was obtained over most of the New York test site flight lines. The correlation between the vertical and horizontal polarization was equally good. Statistically meaningful correlation between airborne microwave data and available soil-moisture measurements was not obtained because of (a) probable nonspecular scattering and attenuation associated with surface vegetation and (b) lack of sufficiently detailed ground measurements. Significant changes in the microwave brightness temperature were observed at Scipio, N.Y., along the flight track before and after precipitation.

The problem of modeling the microwave scattering remains a severe one, although large amounts of data now exist for the New York test sites. The data have been organized into two volumes, one containing ground truth, the other containing information taken from aerial surveys.

Future plans include a continuing search for the proper program for computer compatible tape digital printouts of soil-moisture effect on reflectance in the Scipio, N. Y., area.

71. *Distribution, Abundance, and Composition of Invertebrate Fish Forage Mechanisms in Lake Ontario*

Principal Investigator: J.F. Carr - Great Lakes Fisheries Laboratory

No report.

72. *Coastal Circulation in the Great Lakes*

Principal Investigator: G.T. Csanady - Woods Hole Oceanographic Institute

No report.

73. *Lake Water Characteristics*

Principal Investigator: A.P. Pinsak - LSC/NOAA

Analyses of water samples collected by the *Researcher* for LSC during IFYGL cruises 14, 20, 25, and 29 in 1972 have been completed, verified, and put on Hollerith cards. These data have been recorded on a seven-track magnetic tape and are available through the Data Center at CEDDA. Entries on the tape by station location and time include sample depth and temperature, phosphate, nitrate, sulphate, silica, chloride, calcium, magnesium, sodium, potassium, alkalinity, specific conductance, pH, and Eh. Nonfilterable residue is also included under the same station format. The intent is to use these data, in combination with the other lake chemistry data when they become available, for developing a lake materials balance as a part of the chemistry and biology program.

74. *Snow Observation Network*

Principal Investigator: R.B. Sykes - State University of New York at Oswego

Plans have been made for a followup snowfall study in the area east and northeast of where the Oswego weather radar was situated from

April 1, 1972, to March 18, 1973. The radar was located just west of Fulton, N.Y. Snowfall during the time the radar was in operation was generally light and infrequent. A small-scale weather observing and snowfall measuring project that supported the weather radar failed to attain its full potential for several reasons, including poor snowfall conditions. In the limited followup project during the winter of 1973-74, some recording gages and a few observers will be used. Contacts have been made with prospective observers, and initial distribution of equipment and supply has been made. An experimental operational period in late November and early December is expected to be followed by about 2 to 2 1/2 months of routine and specialized operations, which will include determining water equivalent of snowfall, obtaining replicas of ice crystals, taking some photographs, and making some ground-truth measurements by using motor vehicles with intercommunication equipment.

75. *Lake Circulation Model*

Principal Investigator: J.R. Bennett - IFYGL Project Office/NOAA

The three-dimensional lake model and two submodels derived from it, one cross-sectional and the other vertically integrated, have been programmed. Verification studies have begun based on data from July and August 1972. Part of this verification consists of determining the optimum values of three empirical parameters contained in a simple scheme by which the mixing coefficients can be calculated as a function of wind stress, depth, and stratification. The models are also being used to evaluate the theory of K.O. Emery and G.T. Csanady ("Surface Circulation of Lakes and Nearly Land-Locked Seas," Proceedings of the National Academy of Sciences, USA, Vol. 70, No. 1, January 1973, pp. 93-97.)

76. *Lake Ontario Invertebrate Fauna List*

Principal Investigator: A. Robertson - IFYGL Project Office/NOAA

A provisional list has been developed. Work will begin during the next quarter on estimating the distribution and abundance of the various forms within Lake Ontario.

77. *Natural Distribution and Variability of Physical Properties*

Principal Investigators: E. Aubert, J. Harrison, and R. Pickett - IFYGL Project Office/NOAA

A working data base is under development on IBM 3330 random access disk pack to support this and other projects requiring access to specific data sets. The data base as currently conceived will contain time-series

station data on physical limnological, hydrological, and surface meteorological parameters for the Field Year. It now includes Canadian current buoy and meteorological buoy data sets. The Physical Data Collection System (PDCS) data set will be added soon.

Analysis to date has consisted of editing water temperature observations by the PDCS for July 1972 and the development and/or acquisition of techniques and software for filtering and spectral analysis applicable to time-series data with intermittent records. Power spectra and cross-spectra for five stations in July show that all of them have temperature spectra consisting of two spikes: at the various depths, one after 50 hr and the other just before the inertial period; at the surface, one after 50 hr and the other at diurnal periods. At each station all levels below the surface oscillate at the same subinertial frequency, but the frequency varies from station to station and ranges from 12 to 17 hr. The subinertial frequencies are not coherent over any spacing between the five PDCS stations. Diurnal oscillations are coherent over all stations. A low (frequency) pass filtered time-series plot of temperature at one station indicates a dramatic temporal intermittency -- a significant increase in the amplitude of the subinertial oscillations near the thermocline, presumably related to the impact of a late July storm.

78. *Carbon Cycle Model*⁵

Principal Investigators: A. Robertson and B. Eadie - IFYGL Project Office/NOAA

Objectives of this task are the following:

- (1) To estimate the budget for the element carbon for Lake Ontario.
- (2) To increase our understanding of the movement of this element within this lake.
- (3) To develop a model that allows prediction of the amounts of carbon within various ecologically meaningful subdivisions, e.g., phytoplankton, nonliving particulate organic matter, carbonate ion.

Project Areas

Biology and Chemistry - N.A. Thomas, U.S. Panel Cochairman

A meeting was held by the U.S. Biology and Chemistry Panel members on September 27, 1973, in Detroit, Mich. The status of all individual

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This is a new task initiated in September 1973.

tasks were reviewed, and schedules for completion were presented. Generally, most of the work is progressing on schedule, with the bulk of it to be completed by April 1974. The U.S. investigators expressed a desire to issue as soon as possible some type of publication delineating findings to date. Most of the investigators also expressed a need to have the major part of the physical and chemical data made available in a worked-up form.

Boundary Layer - J.Z. Holland, U.S. Panel Cochairman

During this quarter, the main effort by members of the panel was placed on continued data processing, validation, and analyses of results for their respective tasks.

Terrestrial Water Balance - B.G. DeCooke, U.S. Panel Cochairman

During the reporting period, reduction and correlation of data under the various tasks continued. Because of delays in receiving data and manpower shortages little was accomplished on several tasks.

Work continued on preparing first-cut estimates of monthly evaporation from the lake. Plans are to complete first-cut estimates of evaporation for the Field Year early during the next quarter.

Based on provisional data furnished the Terrestrial Water Balance Panel, the monthly evaporation from the water surface of Lake Ontario is estimated to be as follows:

<u>Month</u>		<u>Evaporation</u> (in)	<u>Month</u>		<u>Evaporation</u> (in)
April	1972	0.4	October	1972	5.2
May	"	0.6	November	"	2.7
June	"	1.0	December	"	2.2
July	"	2.1	January	1973	3.2
August	"	3.6	February	"	1.8
September	"	3.8	March	"	0.2

Further estimates will not be made until final data are available.

DATA MANAGEMENT

Physical Data Collection System (PDCS)

Provisional PDCS data for July 1972 are available. They represent a merge of real-time, RCC weekly tape, and on-board cassette data with all calibrations applied. No editing has been done, and gross errors may be present. Provisional data for October are in the final processing stage and will become available around December 1, 1973. The Provisional Data Base for the entire Field Year will be available by mid-June 1974, with monthly increments available in the interim.

Editing of the data for the generation of the PDCS Final Data Base will be both manual and automatic.

The manual editing will consist of studying the PDCS event logs, provisional time-series graphics, and 6-min graphics. Any data that are obviously incorrect will be deleted from the final data set, but they will still appear in the Provisional Data Base. In the automatic editing process, each type of PDCS data will be passed through windows or ranges of acceptable values. Any value that lies outside the sensor's range or is unreasonable in physical terms will be deleted.

Hourly averages for air and water temperature, atmospheric pressure, pan evaporation, and dew point will be computed in the usual manner. The standard deviation of the average will also be calculated. The sample used to compute the hourly average begins 30 min before the hour and ends 29 min after the hour. Each observation that deviates from the mean by more than 1.5 standard deviations will be deleted from the computation, and a new mean will be computed. This routine will be iterated until two successive means (\bar{x}_i and \bar{x}_{i+1}) differ by less than sensor's resolution or until only 50 percent of the starting number of observations remain. The hourly average \bar{x}_i , its associated standard deviation, and the number of points used to compute the mean will be recorded.

Hourly averages for wind and current speed and direction will be computed as follows:

$$|V| = \left[\frac{\bar{u}^2}{\bar{v}} + \frac{\bar{v}^2}{\bar{v}} \right]^{1/2},$$

$$\bar{D} = \tan^{-1} \frac{\bar{u}}{\bar{v}},$$

where

$$\bar{u} = \frac{\sum u}{n}$$

$$\bar{v} = \frac{\sum v}{n}$$

$$n = \leq 10$$

$$u = -(s_o)(\sin d_o)$$

$$v = -(s_o)(\cos d_o)$$

s_o being the observed speed and d_o the observed direction.

If either s_o or d_o is missing for a 6-min observation, that observation is treated as missing.

Hourly averages for precipitation and radiation (long and short wave) will not be computed. Instead, an hourly total for each parameter will be recorded, along with the number of observations.

The final edited data will be available in several forms:

- (1) Microfilm graphics display of each day's data for each sensor. The frames will be divided into three parts: (a) title and location; (b) unedited 6-min provisional values for the entire day; and (c) edited 6-min values.
- (2) Time-series graphics, on microfilm, of the final edited 6-min observations.
- (3) Microfilm display of hourly averages and standard deviations (or hourly totals) and the number of observations used to compute them.
- (4) BCD tapes (two per 8-day period) of the edited 6-min observations. These tapes will be in the same format as the provisional tapes.
- (5) BCD tapes (1 per 8-day period) of the hourly averages and/or totals.

IFYGL PUBLICATIONS POLICY AND FORMAT

Policy

Official policy with regard to publications related to IFYGL remains as stated in IFYGL Bulletin No. 4, pp. 115-116. Some additional comments are made here regarding format in response to inquiries by IFYGL investigators.

Format

Except for the IFYGL Bulletin series, all IFYGL publications (e.g., Scientific Reports and Technical Manuals) will be 8 1/2 by 11 in in size, with a standard cover carrying the officially designated IFYGL symbol. In the preparation of such reports, detailed guidance will be given the authors, through coordination between the IFYGL Centre, CCIW, and the U.S. IFYGL Project Office, NOAA.

No standard format can be established for Project Reports, since these may be published in scientific and technical journals, or as Contract Reports. Each report should, however, include the following in order to acknowledge its relationship to the Field Year program:

- (1) A statement to the effect that the study was undertaken as a part of the International Field Year for the Great Lakes, a joint United States-Canadian (or Canadian-United States) contribution to the International Hydrological Decade.
- (2) An indication of the relationship of the study to the overall IFYGL program and the appropriate major components of IFYGL.
- (3) Acknowledgment of logistic support and assistance.
- (4) When appropriate, acknowledgment of funding for the study.
- (5) When possible, use of the IFYGL symbol on the cover of a report, or on maps and illustrations to emphasize the cooperative nature of the Field Year program.

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- Scott, J.T. "Basic Data for the Olcott Coastal Chain," Report 1 c, U.S. IFYGL Coastal Chain Program, Atmospheric Sciences Research Center, State University of New York at Albany, Report No. 227 c, 1973, 306 pp.
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- Wilson, J.W., "Measurement of Snowfall by Radar," Preprint of Paper Presented at Interdisciplinary Symposium on Advanced Concepts and Techniques in the Study of Snow and Ice Resources, Monterey, California, 1973, 4.3-1 to 4.3-11.



